REPORT

OF THE

EIGHTEENTH ANNUAL MEETING

OF THE

SOUTH AFRICAN ASSOCIATION

FOR THE ADVANCEMENT OF SCIENCE,

BEING VOLUME XVII OF THE SOUTH AFRICAN JOURNAL OF SCIENCE.

BULAWAYO

1920.

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1921.

CONTENTS.

Papers Read (*continued*):—

LIST OF PLATES.

Erratum.—Owing to an error in the typing of the author's MS., the figure 100 on line 14 of page 175 should read 1000.

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THE

SOUTH AFRICAN JOURNAL OF SCIENCE,

COMPRISING THE REPORT OF THE

SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

(1920, BULAWAYO.)

VOL. XVII. NOVEMBER, 1920. No. 1.

CONSTITUTION

OF THE

SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

[*As amended at the Eighteenth Annual Meeting at Bulawayo, 1920*].

I.—OBJECTS.

The objects of the Association are :—To give a stronger impulse and a more systematic direction to scientific enquiry; to promote the intercourse of societies and individuals interested in Science in different parts of South Africa; to obtain a more general attention to the objects of pure and applied Science, and the removal of any disadvantages of a public kind which may impede its progress.

II.—MEMBERSHIP.

(*a*) All persons interested in the objects of the Association are eligible for Membership.

(*b*) Institutions, Societies, Government Departments and Public Bodies are eligible as "Institutional Members."

(*c*) The Association shall consist of (a) Life Members, (b) Ordinary Members (both of whom shall be included under the term "Members"), (c) Institutional Members, and (d) Temporary Members, elected for a session, hereinafter called "Associates."

(*d*) Members, Institutional Members, and Associates shall be elected directly by the Council, but Associates may also be elected by Local Committees. Members may also be elected by a majority of the Members of Council resident in that centre at which the next ensuing session is to be held.

(*e*) The Council shall have the power, by a two-thirds vote, to remove the name of a member of any class whose Membership is no longer desirable in the interests of the Association.

III.—PRIVILEGES OF MEMBERS AND ASSOCIATES.

(*a*) Life Members shall be eligible for all offices of the Association, and shall receive gratuitously all ordinary publications issued by the Association.

(*b*) Ordinary Members shall be eligible for all offices of the Association, and shall receive *gratuitously* all ordinary publications issued by the Association during the year of their admission, and during the years in which they continue to pay, *without intermission*, their Annual Subscription.

(*c*) Institutional Members shall receive *gratuitously* all ordinary publications of the Association on the same conditions as ordinary members; and each Institutional Member shall be entitled to send one representative to the Annual Session of the Association.

(*d*) Associates are eligible to serve on the Reception Committee, but are not eligible to hold any other office, and they are not entitled to receive gratuitously the publications of the Association.

(*e*) Members and Institutional Members may purchase from the Association (for the purpose of completing their sets) any of the Annual Reports of the Association, at a price to be fixed upon by the Council.

IV.—SUBSCRIPTIONS.

(*a*) Every Life Member shall pay, on admission as such, the sum of Ten Pounds.

(*b*) Ordinary and Institutional Members shall pay, on election, an Annual Subscription of One Pound. Subsequent Annual Subscriptions shall be payable on the first day of July in each year.

(*c*) An Ordinary Member may at any time become a Life Member by one payment of Ten Pounds in lieu of future Annual Subscriptions. An Ordinary Member may, after ten years, provided that his subscriptions have been paid regularly without intermission, become a Life Member by one payment of Five Pounds in lieu of future Annual Subscriptions.

(*d*) The Subscription for Associates for a Session shall be Ten Shillings.

V.—MEETINGS.

The Association shall meet in Session Annually. The place of meeting shall be appointed by the Council as far in advance as possible, and the arrangements for it shall be entrusted to the Local Committee, in conjunction with the Council.

VI.—COUNCIL.

(*a*) The Management of the affairs of the Association shall be entrusted to a Council, five to form a quorum.

(*b*) The Council shall consist of the President, Retiring President, four Vice-Presidents, two General Secretaries, the General Treasurer, the Editor of the publications of the Association, and the Librarian, together with one Member of Council for every twenty Members of the Association.

(*c*) The President, Vice-Presidents, General Secretaries, General Treasurer, the Editor of the publications of the Association and the Librarian shall be nominated at a meeting of Council not later than two months previous to the Annual Session, and shall be elected at the Annual General Meeting.

(*d*) Ordinary Members of Council to represent centres having more than twenty Members shall, not later than one month prior to the Annual Session of the Association, be elected by each such Centre, in the proportion of one representative for every twenty Members. The Annual General Meeting shall elect other Ordinary Members of Council, in number so as to give, together with the Members of Council already elected by the Centres, in all, one Member of Council for every twenty Members of the Association.

(*e*) The Council shall have the power to co-opt Members, not exceeding five in number, from among the Members of the Association resident in that Centre at which the next ensuing Session is to be held.

(*f*) In the event of a vacancy occurring in the Council, or among the Officers of the Association, in the intervals between the Annual Sessions, or in the event of the Annual Meeting leaving vacancies, the Council shall have the power to fill such vacancies.

(*g*) During any Session of the Association the Council shall meet at least twice, and the Council shall meet at least six times during the year, in addition to such Meetings as may be necessary during the Annual Session of the Association.

(*h*) The Council shall have the power to pay for the services of Assistant General Secretaries, for such clerical assistance as it may consider necessary, and for such assistance as may be needed for the publication of the Association Report or Journal.

(*i*) The Council shall have power to frame Bye-laws to facilitate the practical working of the Association, so long as these Bye-laws are not at variance with the Constitution.

VII.—LOCAL AND RECEPTION COMMITTEES.

(*a*) A Local Committee shall be constituted for the Centre at which the Annual Session is to be held, and shall consist of the Members of the Council resident in that Centre, with such other Members of the Association as the said Members of Council may elect.

(*b*) The Local Committee shall form a Reception Committee to assist in making arrangements for the reception and entertainment of visitors. Such Reception Committee may include persons not necessarily Members or Associates of the Association.*

(*c*) The Local Committee shall be responsible for all expenses in connection with the Annual Session of the Association.

VIII.—HEADQUARTERS.

The Headquarters of the Association shall be in Johannesburg.

IX.—FINANCE.

(*a*) The Financial Year shall end on the 31st of May.

(*b*) All sums received for Life Subscriptions and for Entrance Fees shall be invested in the names of three Trustees appointed by the Council, and only the interest arising from such investment shall be applied to the uses of the Association, except by resolution of a General Meeting; provided that any composition fee as a Life Member paid over to the Trustees of the Endowment Fund after the 30th day of May, 1914, may, upon the death of such Member, be repaid by the Trustees to the General Account of the Association, if the Council shall so decide.

(*c*) The Local Committee of the Centre in which the next ensuing Session is to be held shall have the power to expend money collected, or otherwise obtained in that Centre, other than the subscriptions of Members. Such disbursements shall be audited, and the financial statement and the surplus funds forwarded to the General Treasurer within one month after the Annual Session.

(*d*) All cheques shall be signed by the General Treasurer and a General Secretary, or by such other person or persons as may be authorised by the Council.

(*e*) Whenever the balance in the hands of the Treasurer shall exceed the sum requisite for the probable or current expenses of the Association, the Council shall invest the excess in the names of the Trustees.

(*f*) On the request of the majority of the Members of Council of any Centre in which two or more Members of Council reside, the Council shall empower the local Members of Council in that Centre to expend sums not exceeding in the aggregate 10 per centum of the amount of Annual Subscriptions raised in that Centre.

(*g*) The whole of the accounts of the Association, *i.e.*, the local as well as the general accounts, shall be audited annually by an auditor appointed by the Council, and the balance-sheet shall be submitted to the Council at the first meeting thereafter, and be printed in the Annual Report of the Association.

* The Reception Committee should make arrangements to provide:—

(1) A large hall for the delivery of the Presidential Address and evening lectures.

(2) A large room to be used as a Reception Room for members and others, at which all information regarding the Association can be obtained, and which shall have attached to it two Secretaries' Offices, a Writing Room for members and others, a Smoking Room, and Ladies' Room.

(3) Six rooms, each capable of accommodating about 30 or 40 people, to be used as Sectional Meeting Rooms, and, if possible, to have rooms attached, or in close proximity, for the purpose of holding meetings of Sectional Committees.

(4) Other requirements, such as office furniture, blackboards, window blinds to darken sectional meeting rooms for Lantern lectures, notice boards, etc.

X.—SECTIONS OF THE ASSOCIATION.

The Scientific Work of the Association shall be transacted under such sections as shall be constituted from time to time by the Council, and the constitution of such Sections shall be published in the Journal.

The Sections shall deal with the following Sciences and such others as the Council may add thereto from time to time:—Agriculture; Anthropology and Ethnology; Archæology; Architecture; Anatomy; Astronomy; Bacteriology; Botany; Chemistry; Education; Engineering; Eugenics; Geodesy and Surveying; Geography, Geology and Mineralogy; Irrigation; Mathematics; Mental Science; Meteorology; Philology; Physics; Physiology; Political Economy; Sanitary Science; Sociology; Statistics; Zoology.

XI.—RESEARCH COMMITTEES.

(*a*) Grants may be made by the Association to Committees or to individuals for the promotion of Scientific research.

(*b*) Every proposal for special research, or for a grant of money in aid of special research shall primarily be considered by the Sectional Committee dealing with the science specially concerned, and if such proposal be approved, shall be referred to the Council.

(*c*) A Sectional Committee may recommend to Council the appointment of a Research Committee, composed of Members of the Association, to conduct research or to administer a grant in aid of research.

(*d*) In recommending the appointment of Research Committees, the Sectional Committee shall specifically name all Members of such Committees; and one of them, who has notified his willingness to accept the office, shall be appointed to act as Secretary. The number of Members appointed to serve on a Research Committee shall be as small as is consistent with its efficient working.

(*e*) All recommendations adopted by Sectional Committees shall be forwarded without delay to the Council for consideration and decision.

(*f*) Research Committees shall be appointed for one year only, but if the work of a Research Committee cannot be completed in that year, application may be made, through a Sectional Committee, at the next Annual Session for re-appointment, with or without a grant—or a further grant—of money.

(*g*) Every Research Committee, and every individual, to whom a grant had been made, shall present to the following Annual Meeting a report of the progress which has been made, together with a statement of the sums which have been expended. Any balance shall be returned to the General Treasurer.

(*h*) In each Research Committee, the Secretary thereof shall be the only person entitled to call on the Treasurer for such portions of the sums granted as may from time to time be required.

XII.—SPECIAL COMMITTEES.

The Council shall have power to appoint Special Committees to deal with such subjects as it may approve, to draft regulations for any such Committees, and to vote money to assist the Committees in their work.

XIII.—SECTIONAL COMMITTEES.

(*a*) The Sectional Committees shall consist of a President, two Vice-Presidents, two or more Secretaries, and such other persons as the Council may consider necessary, who shall be elected by the Council. Of the Secretaries, one shall act as Recorder of the Section, and at least one shall be resident in the Centre where the Annual Session is to be held.

(*b*) From the time of their election, which shall take place as soon as possible after the Session of the Association, they shall form themselves into an organising Committee for the purpose of obtaining information upon Papers likely to be submitted to the Sections, and for the general furtherance of the work of the Sectional Committees.

(*c*) The Sectional Committees shall have power to add to their number from among the Members of the Association.

(*d*) The Committees of the several Sections shall determine the acceptance of Papers before the beginning of the Session, keeping the General Secretaries informed from time to time of their work. It is therefore desirable, in order to give an opportunity to the Committees of doing justice to the several communications, that each author should prepare an Abstract of his Paper,

and he should send it, together with the original Paper, to the Secretary of the Section before which it is to be read, so that it may reach him at least a fortnight before the Session.

(*e*) Members may communicate to the Sections the Papers of non-members.

(*f*) The Author of any Paper is at liberty to reserve his right of property therein.

(*g*) The Sectional Committees shall meet not later than the first day of the Session in the Rooms of their respective Sections, and prepare the programme for their Sections and forward the same to the General Secretaries for publication.

(*h*) The Council cannot guarantee the insertion of any Report, Paper or Abstract in the Annual Volume unless it be handed to the Secretary of the Section before the conclusion of the Session.

(*i*) The Sectional Committees shall report to the Council what Reports, Papers or Abstracts it is thought advisable to print, but the final decision shall rest with the Council.

XIV.—ALTERATION TO RULES.

Any proposed alteration of the Rules—

a. Shall be intimated to the Council three months before the next Session of the Association.

b. Shall be duly considered by the Council and communicated by Circular to the Members of the Association for their consideration, and dealt with at the said Session of the Association.

During the interval between two Annual Sessions of the Association, any alterations proposed to be made in the Rules shall be valid if agreed to by two-thirds of the Members of Council. Such alteration of Rules shall not be permanently incorporated in the Constitution until approved by the next Annual Meeting.

XV.—VOTING.

In voting for Members of Council, or on questions connected with Alterations to Rules, absent Members may record their vote in writing.

RULES FOR THE AWARD OF MEDALS.

A. The South Africa Medal.

I.—Constitution of Committee.

(*a*) The Council of the South African Association for the Advancement of Science shall, annually and within three months after the close of the Annual Session, elect a Committee to be called "the South Africa Medal Committee," on which, as far as possible, every Section of the Association and each Province of South Africa shall have fair representation.

(*b*) This Committee shall consist of eight Members elected from amongst Council Members, together with four other Members, selected from amongst Members of the Association who are not on the Council.

(*c*) Each new Committee shall retain not less than four members who have served on the previous Committee.

(*d*) The Chairman of the Committee shall be appointed annually by the Council from amongst its Members.

(*e*) Any casual vacancy in the Committee shall be filled by the Council

II.—Duties.

(*a*) The duties of the Committee shall be to administer the Income of the Fund and to award the Medal, raised in commemoration of the visit of the British Association to South Africa in 1905, in accordance with the resolution of its Council.

(*b*) This resolution reads as follows:

(1) That, in accordance with the wishes of subscribers, the South Africa Medal Fund be invested in the names of the Trustees appointed by the South African Association for the Advancement of Science.

(2) That the Dies for the Medal be transferred to the Association, to which, in its corporate capacity, the administration of the Fund

and the award of the Medal shall be, and is hereby, entrusted, under the conditions specified in the Report to the Medal Committee.

(*c*) The terms of conveyance are as follows:—

(1) That the Fund be devoted to the preparation of a Die for a Medal, to be struck in Bronze, $2\frac{1}{2}$ inches in diameter; and that the balance be invested and the annual income held in trust.

(2) That the Medal and income of the Fund be awarded by the South African Association for the Advancement of Science for achievement and promise in scientific research in South Africa.

(3) That, so far as circumstances admit, the award be made annually.

(*d*) The British Association has expressed a desire that the award shall be made only to those persons whose Scientific work is likely to be usefully continued by them in the future.

III.—Awards.

(*a*) Any individual engaged in Scientific research in South Africa shall be eligible to receive the award.

(*b*) The Medal and the available balance of one year's income from the Fund shall be awarded to one candidate only in each year (save in the case of joint research); to any candidate once only; and to no member of the Medal Committee.

(*c*) Nominations for the recipient of the award may be made by any Member of the South African Association for the Advancement of Science, and shall be submitted to the Medal Committee not later than six months after the close of the Annual Session.

(*d*) The Medal Committee shall recommend the recipient of the award to the Council, provided the recommendation is carried by the vote of at least a majority of three-fourths of its Members, voting verbally or by letter, and submitted to the Council at least one month prior to the Annual Session for confirmation.

(*e*) The award shall be made by the full Council of the South African Association for the Advancement of Science after considering the recommendations of the Medal Committee, provided it is carried by the vote of a majority of its Members, given in writing or verbally.

(*f*) The Council shall have the right to withhold the award in any year, and to devote the funds rendered available thereby in a subsequent award or awards, provided the stipulation contained in the second term of conveyance of the British Association is adhered to.

(*g*) No alteration shall be made in these Rules except under the condition specified in Chapter XIV. of the Association's Constitution, reading:—

Any proposed alteration of the Rules—

a. Shall be intimated to the Council three months before the next Session of the Association.

b. Shall be duly considered by the Council, and be communicated by circular to the Members of the Association for their consideration, and dealt with at the said Session of the Association.

(*h*) Should a Member of the Medal Committee accept nomination for the Award or be absent from South Africa at any time within four months before the commencement of the ensuing Annual Session, he will, *ipso facto*, forfeit his seat on the Committee.

B. The Goold-Adams Medals.*

(*a*) The Medals shall be awarded on the joint results of the Matriculation and University Senior Certificate Examinations of the University of the Cape of Good Hope.

(*b*) One Medal shall be awarded to the student who has taken the highest place in each of the seven Science subjects: (1) Physics, (2) Chemistry, (3) Elementary Physical Science, (4) Botany, (5) Zoology, (6) Elementary Natural Science, and (7) Mathematics, as set forth in the University

* The award of these medals is at present suspended.

Matriculation Examination and the University Senior Certificate Examination; and who is not over the prescribed age for Exhibitions at the Matriculation Examination.

(*c*) The standard of marks shall be not less than 65 per cent. of the maximum.

(*d*) The Medals shall be struck in bronze.

BYE-LAWS.

I. *Bye-laws under which the O.F.S. Philosophical Society was incorporated, from 1st July, 1914, with the South African Association for the Advancement of Science, with the designation of "The Orange Free State Branch" of the Association.*

1. The O.F.S. Philosophical Society to be incorporated with the South African Association for the Advancement of Science, this being the only course of procedure open under the existing Constitution.

2. The title of the Society so incorporated to be "The Orange Free State Branch of the South African Association for the Advancement of Science."

3. All members of the South African Association for the Advancement of Science resident in the Orange Free State will, for purposes of these bye-laws, be considered members of the Orange Free State Branch of the Association.

4. The local Committee of the Branch to consist of the Council members of the Association for the Orange Free State, together with such additional members as the Branch may elect to serve on its local Committee.

5. Subscription notices to members of the Branch to be circulated from the Head Office of the Association in Johannesburg, and subscriptions to be paid to the General Treasurer of the Association at Johannesburg, 10 per cent. thereof being remitted to the Orange Free State Branch for local expenses. Subscriptions of £1 per annum to entitle to membership of the Association as a whole, as well as of the Orange Free State Branch.

6. All members at present on the books of the Orange Free State Philosophical Society to be entitled to become members of the Association, to receive its Journal, and to enjoy the full priviliges of membership, as soon as their subscription of £1 for the financial year 1914-15 shall have been paid.

7. Papers read before the Orange Free State Branch may either (1) be printed by title, abstract, or *in extenso*, in the Journal of the Association for the current year, after reference to the Presidents of the respective Sectional Committees, or (2) be read at the next Annual Session of the Association (provided that they have not been previously published in abstract or *in extenso*), and thereafter printed in the Association's Journal, subject to the ordinary conditions.

II. *Bye-laws for the guidance of Sectional Officers.*

1. The attention of all Sectional Officers is directed to Chapter XIII. of the Association's Constitution, relating to the Sectional Committees and their functions.

2. The President and Recorder (or Secretary) of a Section shall have power during the Annual Session to act on behalf of the Section in any matter of urgency which cannot be brought before the consideration of the whole Sectional Committee; and they shall report such action to the next meeting of the Sectional Committee.

3. The President of the Section, or, in his absence, one of the two Vice-Presidents, shall preside at all meetings of the Section or of the Sectional Committee.

4. The President of the Section is expected to prepare a Presidential Address, which shall be delivered during the Annual Session.

5. Prior to the commencement of the Session, the Recorder of each Section shall prepare a list of all papers notified to be read during the Session,

and shall also keep the Assistant Secretary of the Association informed of the titles and authors of all such papers. The Assistant Secretary shall, on his part, keep the Recorder informed of all papers that may be notified to him direct.

6. When a proposal is made for the reading of a paper at a joint meeting of Sections, the President, Recorder and Secretary of each Section shall, *ex officio*, attend a meeting convened by a General Secretary to consider the same.

7. During the continuance of the Annual Session, the Local Secretary of each Section shall be responsible for the punctual transmission to the Assistant Secretary of the daily programme of his Section for early publication, and of any other recommendations adopted by the Sectional Committee: and shall, at the close of the Session, furnish the Assistant Secretary with a list, showing which of the papers notified for reading before the Section have been so read, and which have been taken as read, and giving the dates in either case. He shall, at the same time, indicate the recommendations of the Sectional Committee with respect to each paper, *i.e.*, whether it should be printed in full, or in abstract, or by title only.

8. Each Sectional Committee shall cause to be prepared a record of the discussion on each paper read at its meeting; and such record shall be attached to the paper and handed in with the same in terms of Clause 11 of these instructions.

9. Each Sectional Committee shall, during the continuance of the Annual Session, meet daily, unless otherwise determined, to complete the arrangements for the next day.

10. In deciding on any recommendation regarding the printing of or otherwise of a paper submitted to it, the Sectional Committee shall consider only the merits of the paper, and not the financial condition of the Association.

11. The Local Secretary of each Section shall, at the close of each day, collect the papers that have been read and hand them to the Assistant Secretary, together with a note explaining the cause of absence of any paper not so handed over.

12. Sectional Officers shall do their utmost to ensure punctual commencement and termination of the Section's daily proceedings; and, in drafting the programme for the next day, the Committee shall endeavour to allot a specified time to the reading and discussion of each paper, in order to prevent other Sections or the Association as a whole being inconvenienced in consequence of delays.

III. *Bye-laws for the Affiliation of Scientific and Kindred Societies.*

Philosophical and Scientific Societies, and other Associations of a kindred character may, on application to, and with the approval of the Council, affiliate with the South African Association for the Advancement of Science on the following conditions:

1. That as a Society can only be affiliated on the approval of the Council, no minimum of membership of such Society need be specified.

2. That each Society shall pay the Association a minimum fee of £5 for a strength of 50 members or less, and a further £1 for each additional 10 or portion of 10 members.

3. That such Society shall be entitled to one copy of the South African Journal of Science for each £1 paid to the Association.

4. That such Society may, if it has a strength of 50 members, be represented on the Council of the Association by its President or such other member as may be nominated for the purpose.

5. That all members of affiliated Societies may join the Association as ordinary members, with full privileges, at a reduced annual subscription of 15s.

6. That affiliated Societies shall be asked to take into consideration the admission of members of the Association into their Societies at a reduced subscription.

7. That papers contributed to affiliated Societies may, on recommendation of both their own Council and that of the Association, be printed in the Association's JOURNAL OF SCIENCE, after which the authors shall be entitled to reprints on the usual terms.

Table showing the Places and Dates of Meeting of the South African Association, with Presidents, Vice-Presidents, and Local Secretaries, from its Foundation.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
Sir DAVID GILL, K.C.B., LL.D., F.R.S., F.R.S.E. Cape Town, April 27, 1903.	S. J. Jennings, M.Amer.I.M.E., M.I.M.E. Sir Charles Metcalfe, Bart., M.I.C.E. Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E. Gardner F. Williams, M.A.	J. D. F. Gilchrist, M.A., D.Sc., Ph.D., F.L.S.
Sir CHARLES METCALFE, Bart., M.I.C.E. Johannesburg, April 4, 1904.	J. Fletcher, A.M.I.C.E. S. J. Jennings, M.Amer.I.M.E., M.I.M.E. Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E. Gardner F. Williams, M.A.	T. Reunert, M.I.C.E., M.I.M.E.
THEODORE REUNERT, M.I.C.E., M.I.M.E. Johannesburg, August 28, 1905.	J. Fletcher, A.M.I.C.E. S. J. Jennings, M.Amer.I.M.E., M.I.M.E. Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E. Gardner F. Williams, M.A.	W. Cullen.
GARDNER F. WILLIAMS, M.A. Kimberley, July 9, 1906.	J. Burtt-Davy, F.L.S., F.R.G.S. James Hyslop, D.S.O., M.B., C.M. S. J. Jennings, M.Amer.I.M.E., M.I.M.E., M.I.M.M. Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E.	W. M. Wallace, A.R.C.S., A.M.I.C.E.
JAMES HYSLOP, D.S.O., M.B., C.M. Durban, July 16, 1907.	J. Burtt-Davy, F.L.S., F.R.G.S. S. J. Jennings, M.Amer.I.M.E., M.I.M.E., M.I.M.M. Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E. Prof. S. Schönland, M.A., Ph.D., F.L.S., C.M.Z.S.	C. W. P. Douglas de Fenzi.
H.E. the Hon. Sir WALTER HELY-HUTCHINSON, G.C.M.G., LL.D. Grahamstown, July 6, 1908.	Prof. J. C. Beattie, D.Sc., F.R.S.E. S. J. Jennings, M.Amer.I.M.E., M.I.M.E., M.I.M.M. Prof. S. Schönland, M.A., Ph.D., F.L.S., C.M.Z.S. Ernest Williams, A.M.I.C.E., M.I.M.M.	Prof. J. E. Duerden, M.Sc., Ph.D., A.R.C.S. W. Hammond Tooke.
H.E. Sir HAMILTON GOOLD-ADAMS, G.C.M.G., C.B. Bloemfontein, September 27, 1909.	J. Burtt-Davy, F.L.S., F.R.G.S. Hugh Gunn, M.A. R. Marloth, M.A., Ph.D. Prof. S. Schönland, M.A., Ph.D., F.L.S., C.M.Z.S.	Prof. G. Potts, M.Sc., Ph.D. A. Stead, B.Sc., F.C.S.
THOMAS MUIR, C.M.G., M.A., LL.D., F.R.S., F.R.S.E. Cape Town, October 31, 1910.	W. Cullen Hugh Gunn, M.A. Prof. P. D. Hahn, M.A., Ph.D. J. M. P. Muirhead, F.S.S., F.R.S.E.	C. F. Juritz, M.A., D.Sc., F.I.C.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
Professor PAUL DANIEL HAHN, M.A., Ph.D. Bulawayo, July 3, 1911.	Prof. L. Crawford, M.A., D.Sc., F.R.S.E. C. W. Howard, B.A., F.E.S. A. J. C. Molyneux, F.G.S., F.R.G.S. A. Theiler, C.M.G.	G. N. Bromehead.
ARNOLD THEILER, C.M.G., D.Sc. Port Elizabeth, July 1, 1912.	Prof. L. Crawford, M.A., D.Sc., F.R.S.E. J. Moir, M.A., D.Sc., F.C.S. A. J. C. Molyneux, F.G.S., F.R.G.S. W. Arnott	E. G. Bryant, B.A., B.Sc.
ALEXANDER W. ROBERTS, D.Sc., F.R.A.S., F.R.S.E. Lourenço Marques, July 7, 1913.	Prof. L. Crawford, M.A., D.Sc., F.R.S.E. R. T. A. Innes, F.R.A.S., F.R.S.E. A. J. C. Molyneux, F.G.S., F.R.G.S. J. H. von Hafe	H. E. Wood, M.Sc., F.R.Met.S.
Professor RUDOLF MARLOTH, M.A., Ph.D. Kimberley, July 6, 1914.	Prof. L. Crawford, M.A., D.Sc., F.R.S.E. S. Evans W. Johnson, L.R.C.P., L.R.C.S. A. F. Williams, B.Sc.	A. F. Williams, B.Sc. F. Harrison.
ROBERT T. A. INNES, F.R.A.S., F.R.S.E. Pretoria, July 5, 1915.	Prof. L. Crawford, M.A., D.Sc., F.R.S.E. G. W. Herdman, M.A., M.I.C.E. Sir Arnold Theiler, K.C.M.G., D.Sc. A. H. Watkins, M.D., M.R.C.S., M.L.A.	E. Hope Jones.
Professor LAWRENCE CRAWFORD, M.A., D.Sc., F.R.S.E. Maritzburg, July 3, 1916.	Rev. W. Flint, D.D. Lieut.-Col. J. Hyslop, D.S.O., M.B., C.M. Prof. J. Orr, B.Sc., M.I.C.E. Sir A. Theiler, K.C.M.G., D.Sc.	Prof. W. N. Roseveare, M.A.
Professor JOHN ORR, B.Sc., M.I.C.E., M.I.Mech.E. Stellenbosch, July 2, 1917.	A. H. Reid, F.R.I.B.A., F.R.San.I. Prof. W. N. Roseveare, M.A. Prof. E. H. L. Schwarz, A.R.C.S., F.G.S. H. E. Wood, M.Sc., F.R.Met.S.	Prof. B. de St. J. van der Riet, M.A., Ph.D.
CHARLES F. JURITZ, M.A., D.Sc., F.I.C. Johannesburg, July 8, 1918.	W. Ingham, M.I.C.E., M.I.M.E. A. H. Reid, F.R.I.B.A., F.R.San.I. Prof. W. N. Roseveare, M.A. H. E. Wood, M.Sc., F.R.Met.S.	J. A. Foote, F.G.S., F.E.I.S.
Rev. WILLIAM FLINT, D.D. Kingwilliamstown, July 7, 1919.	P. Cazalet, M.I.M.M. Prof. J. L. Duerden, M.Sc., Ph.D., A.R.C.S. W. Ingham, M.I.C.E., M.I.M.E. Prof. E. Warren, D.Sc.	F. A. O. Pym.
ILTYD BULLER POLE-EVANS, M.A., D.Sc., F.L.S. Bulawayo, July 14, 1920.	Prof. J. W. Bews, M.A., D.Sc. Prof. J. E. Duerden, M.Sc., Ph.D. Prof. R. Leslie, M.A., F.S.S. Prof. J. A. Wilkinson, M.A., F.C.S.	D. Niven.

Presidents and Secretaries of the Sections of the Association.

Date and Place.	Presidents.	Secretaries.
SECTION A.—ASTRONOMY, CHEMISTRY, MATHEMATICS, METEOROLOGY AND PHYSICS.		
1903. Cape Town ...	Prof. P. D. Hahn, M.A., Ph.D.	Prof. L. Crawford.
1904. Johannesburg*	J. R. Williams, M.I.M.M., M.Amer.I.M.E.	W. Cullen, R. T. A. Innes.
1906. Kimberley ...	J. R. Sutton, M.A.	W. Gasson, A. H. J. Bourne.
1907. Natal†	E. N. Neville, F.R.S., F.R.A.S., F.C.S.	D. P. Reid, G. S. Bishop.
1908. Grahamstown ...	A. W. Roberts, D.Sc., F.R.A.S., F.R.S.E.	D. Williams, G. S. Bishop.
ASTRONOMY, MATHEMATICS, PHYSICS, METEOROLOGY, GEODESY, SURVEYING, ENGINEERING, ARCHITECTURUE AND GEOGRAPHY.		
1909. Bloemfontein ...	Prof. W. A. D. Rudge, M.A.	H. B. Austin, F. Masey.
1910. Cape Town‡ ...	Prof. J. C Beattie, D.Sc., F.R.S.E.	A. H. Reid, F. Flowers.
1911. Bulawayo ...	Rev. E. Goetz, S.J., M.A., F.R.A.S.	A. H. Reid, Rev. S. S. Dornan.
1912. Port Elizabeth	H. J. Holder, M.I.E.E.	A. H. Reid.
1913. Lourenço Marques	J. H. von Hafe.	Prof. J. Orr, J. Vafi Gomes.
1914. Kimberley ...	Prof. A. Ogg, M.A., B.Sc., Ph.D.	Prof. A. Brown, A. E. H. Dinham-Peren.
1915. Pretoria ...	F. E. Kanthack, M.I.C.E., M.I.M.E.	Prof. A. Brown, J. L. Soutter.
1916. Maritzburg ...	Prof J. Orr, B.Sc., M.I.C.E.	Prof. A. Brown, P. Mesham.
1917. Stellenbosch ...	Prof. W. N. Roseveare, M.A.	Prof. A. Brown, L. Simons.
1918. Johannesburg...	Prof. J. T. Morrison, M.A., B.Sc., F.R.S.E.	Prof. A. Brown, Prof. J. P. Dalton.
1919. Kingwilliamstown.	W. Ingham, M.I.C.E., M.I.M.E.	Dr. J. Lunt, T. G. Caink, J. Powell.
1920. Bulawayo ...	H E. Wood, M.Sc., F.R.A.S.	Prof. J Orr, A. C. Jennings.
SECTION B.—ANTHROPOLOGY, ETHNOLOGY, BACTERIOLOGY, BOTANY, GEOGRAPHY, GEOLOGY, MINERALOGY AND ZOOLOGY.		
1903. Cape Town ...	R. Marloth, M.A., Ph.D.	Prof. A. Dendy.
1904. Johannesburg ...	G. S. Corstorphine, B.Sc., Ph.D., F.G.S.	Dr. W. C. C. Pakes, W. H. Jollyman.
1906. Kimberley ...	Thos. Quentrall, M.I.M.E., F.G.S.	C. E. Addams, H. Simpson.
CHEMISTRY, METALLURGY, MINERALOGY, ENGINEERING, MINING AND ARCHITECTURE.		
1907. Natal	C. W. Methven, M.I.C.E., F.R.S.E., F.R.I B.A.	R. G. Kirkby, W. Paton.
1908. Grahamstown ...	Prof. E. H. L. Schwarz, A.R.C.S., F.G.S.	Prof. G. E. Cory, R. W. Newman, J. Muller.

* Metallurgy added in 1904.

† Geography and Geodesy transferred to Section A and Chemistry and Metallurgy to Section B, ni 1907.

‡ Irrigation added in 1910 and Geography transferred to Section B.

Date and Place.	Presidents.	Secretaries.
CHEMISTRY, BACTERIOLOGY, GEOLOGY, BOTANY, MINERALOGY, ZOOLOGY, AGRICULTURE, FORESTRY, SANITARY SCIENCE.		
1909. Bloemfontein ...	C. F. Juritz, M.A., D.Sc., F.I.C.	Dr. G. Potts, A. Stead.
CHEMISTRY, GEOLOGY, METALLURGY, MINERALOGY AND GEOGRAPHY.		
1910. Cape Town ...	A. W. Rogers, M.A., Sc.D., F.G.S.	J. G. Rose, G. F. Ayers.
1911. Bulawayo ...	A. J. C. Molyneux, F.G.S., F.R.G.S.	J. G. Rose, G. N. Blackshaw.
1912. Port Elizabeth	Prof. B. de St. J. van der Riet, M.A., Ph.D.	J. G. Rose, J. E. Devlin.
1913. Lourenço Marques	Prof. R. B. Young, M.A., D.Sc., F.R.S.E., F.G.S.	Prof. G. H. Stanley, Capt. A. Graça.
1914. Kimberley ...	Prof. G. H. Stanley, A.R.S.M., M.I.M.E., M.I.M.M., F.I.C.	J. G. Rose, J. Parry.
1915. Pretoria ...	H. Kynaston, M.A., F.G.S.	Dr H. C. J. Tietz, Prof. D. F. du Toit Malherbe.
1916. Maritzburg ..	Prof. J. A Wilkinson, M.A., F.C.S.	Dr. H. C. J. Tietz, Prof. J. W Bews.
1917. Stellenbosch ...	Prof. M. M. Rindl, Ing.D.	Dr. H. C. J. Tietz, Prof. B. de St. J. van der Riet.
1918. Johannesburg...	P. A. Wagner, Ing.D., B.Sc.	Dr. H. C. J. Tietz, Dr. J. Moir.
1919. Kingwilliamstown.	H. H. Green, D.Sc., F.C.S.	Prof. J. A. Wilkinson, T. H. Harrison, W. G. Chubb.
1920. Bulawayo ...	F. P. Mennell, F.G.S., M.I.M.M.	J. H. Hutcheon, A. M. MacGregor.
SECTION C.—AGRICULTURE, ARCHITECTURE, ENGINEERING, GEODESY, SURVEYING, AND SANITARY SCIENCE.		
1903. Cape Town ...	Sir Chas. Metcalfe, Bart., M.I.C.E.	A. H. Reid.
1904. Johannesburg*	Lieut.-Colonel Sir Percy Girouard, K.C.M.G., D.S.O.	G. S. Burt Andrews, E. J. Laschinger.
1906. Kimberley ...	S. J. Jennings, C.E., M.Amer.I.M.E., M.I.M.E.	D. W Greatbatch, W. Newdigate.
BACTERIOLOGY, BOTANY, ZOOLOGY, AGRICULTURE AND FORESTRY, PHYSIOLOGY, HYGIENE.		
1907. Natal	Lieut.-Colonel H. Watkins Pitchford, F.R.C.V.S.	W. A. Squire, A. M. Neilson, Dr. J. E. Duerden.
1908. Grahamstown...	Prof. S. Schonland, M.A., Ph.D., F.L.S., C.M.Z.S.	Dr. J Bruce Bays, W. Robertson, C. W. Mally, Dr. L. H. Gough.
1910. Cape Town† ...	Prof. H. H. W. Pearson, M.A., Sc.D., F.L.S.	W. D. Severn, Dr. J. W. B. Gunning.
1911. Bulawayo ...	F. Eyles, F.L.S., M.L.C.	W. T. Saxton, H. G. Mundy.
1912. Port Elizabeth	F. W. FitzSimons, F.Z.S., F.R.M.S.	W. T. Saxton, I. L. Drège.
1913. Lourenço Marques	A. L. M. Bonn, C.E.	F. Flowers, Lieut. J. B Botelho.
1914. Kimberley ...	Prof. G. Potts, M.Sc., Ph.D.	C. W. Mally, W. J. Calder.
1915. Pretoria ...	C. P. Lounsbury, B.Sc., F.E S.	C. W. Mally, A. K. Haagner
1916. Maritzburg ...	I. B. Pole-Evans, M.A., B.Sc., F.L.S.	C. W. Mally, Prof. E. Warren.
1917. Stellenbosch ...	J. Burtt-Davy, F.L.S., F.R.G.S.	C. W. Mally, C. S. Grobbelaar.

* Forestry added in 1904.
† Sanitary Science added in 1910.

Date and Place.	Presidents.	Secretaries.
	BOTANY, BACTERIOLOGY, AGRICULTURE, AND FORESTRY.	
1918. Johannesburg...	C. E. Legat, B.Sc.	Dr. E. P. Phillips, J. Burtt-Davy.
1919. Kingwilliamstown	Ethel M Doidge, M.A., D.Sc., F.L.S.	Dr. E P. Phillips, E. W. Dwyer, Dr. G. Rattray.
1920. Bulawayo ...	T. R. Sim, D Sc., F.L.S.	Dr. E. P. Phillips, Prof. H. A Wager.
	SECTION D.—ZOOLOGY, PHYSIOLOGY, HYGIENE, AND SANITARY SCIENCE.	
1918. Johannesburg...	Prof. E. J. Goddard, B.A., D.Sc.	C. W. Mally, R. J. Ortlepp
1919. Kingwilliamstown	Prof. E. Warren, D.Sc.	C. W. Mally, Dr. J. I. Brownlee, B. H. Dodd.
1920. Bulawayo ..	C. W. Mally, M.Sc., F E.S.	Dr. Annie Porter, P. H. Taylor.
	SECTION E.—ANTHROPOLOGY, ETHNOLOGY, ECONOMICS, SOCIOLOGY, AND STATISTICS.	
1908. Grahamstown...	W. Hammond Tooke	Prof. A S. Kidd.
	ANTHROPOLOGY, ETHNOLOGY, NATIVE EDUCATION, PHILOLOGY, AND NATIVE SOCIOLOGY.	
1917. Stellenbosch ...	Rev. N. Roberts.	Rev. E. W. H. Musselwhite, Prof. J. J. Smith.
1918. Johannesburg...	Rev. W. A. Norton B.A., B.Litt.	Rev. E. W. H. Musselwhite, Rev. G. Evans.
1919. Kingwilliamstown	Rev. J. R. L. Kingon, M.A., F.R.S.E., F.L.S.	Rev. E. W. H. Musselwhite, G. R. Spencer, M. Flemmer.
1920. Bulawayo ...	Rev. H. A. Junod.	N. H Wilson, Rev. N. Jones.
	SECTION F.—ARCHÆOLOGY, EDUCATION, MENTAL SCIENCE, PHILOLOGY, POLITICAL ECONOMY, SOCIOLOGY AND STATISTICS.	
1903. Cape Town ...	Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E.	Prof. H. E. S Fremantle.
1904. Johannesburg...	(Sir Percy Fitzpatrick, M.L.A.), E. B. Sargant, M.A. (Acting).	Howard Pim, J. Robinson.
1906. Kimberley ...	A. H. Watkins, M.D, M.R.C.S.	E. C. Lardner-Burke, E. W. Mowbray.
	ANTHROPOLOGY, ARCHÆOLOGY, ECONOMICS, EDUCATION, ETHNOLOGY, HISTORY, PSYCHOLOGY, PHILOLOGY, SOCIOLOGY, AND STATISTICS.	
1907. Natal	R. D. Clark, M.A.	R. A. Gowthorpe, A. S. Langley, E. A. Belcher.
	ARCHÆOLOGY, EDUCATION, HISTORY, PSYCHOLOGY, AND PHILOLOGY.	
1908. Grahamstown...	E. G. Gane, M.A.	Prof. W. A. Macfadyen, W. D. Neilson.

ANTHROPOLOGY, ETHNOLOGY, EDUCATION, HISTORY, MENTAL SCIENCE, PHILOLOGY, POLITICAL ECONOMY, SOCIOLOGY AND STATISTICS.

Date and Place.	Presidents.	Secretaries.
1909. Bloemfontein ...	Hugh Gunn, M.A.	C. G. Grant, Rev. W. A. Norton.
1910. Cape Town ...	Rev. W. Flint, D.D.	G. B. Kipps, W. E. C. Clarke.
1911 Bulawayo ...	G. Duthie, M.A., F.R.S.E.	G. B. Kipps, W. J. Shepherd.
1912. Port Elizabeth	W. A. Way, M.A.	G. B. Kipps, E. G. Bryant.
1913. Lourenço Marques.	J. A. Foote, F.G.S.	H. Pim, J. Elvas.
1914. Kimberley ...	Prof. W. Ritchie, M.A.	Prof. R. D. Nauta, A. H. J. Bourne.
1915. Pretoria ...	J. E. Adamson, M.A.	Prof. R. D. Nauta, R. G. L. Austin.
1916. Maritzburg ...	M. S. Evans, C.M.G., F.Z.S.	Prof. R. D. Nauta, Prof. O. Waterhouse.

EDUCATION, HISTORY, MENTAL SCIENCE, POLITICAL ECONOMY, GENERAL SOCIOLOGY, AND STATISTICS.

Date and Place.	Presidents.	Secretaries.
1917. Stellenbosch ...	Rev. B. P. J. Marchand, B.A.	Prof. R. D. Nauta, Dr. Bertha Stoneman
1918. Johannesburg...	Prof. T. M. Forsyth, M.A., D.Phil.	Prof. R. D. Nauta, J. Mitchell.
1919. Kingwilliamstown	Prof. R. Leslie, M.A., F.S.S.	Prof. R. D. Nauta, J. Wood, F. J. Cherrigh.
1920. Bulawayo ...	Prof. R. A. Lehfeldt, B.A., D.Sc.	J. Mitchell, B. M. Narbeth.

EVENING DISCOURSES.

Date and Place.	Lecturer.	Subject of Discourse.
1903. Cape Town ...	Prof. W. S. Logeman, B.A., L.H.C.	The Ruins of Persepolis and how the Inscriptions were read.
1904. Johannesburg...	H. S. Hele-Shaw, LL.D., F.R.S., M.I.C.E.	Road Locomotion—Present and Future.
1906. Kimberley ...	Prof. R. A. Lehfeldt, B.A., D.Sc.	The Electrical Aspect of Chemistry.
	W. C. C. Pakes, L.R.C.P., M.R.C.S., D.P.H., F.I.C.	The Immunisation against Disease of Micro-organic Origin.
1907. Maritzburg ...	R. T. A. Innes, F.R.A.S., F.R.S.E.	Some Recent Problems in Astronomy.
Durban ...	Prof. R. B. Young, M.A., B.Sc., F.R.S.E., F.G.S.	The Heroic Age of South African Geology.

Date and Place.	Lecturer.	Subject of Discourse.
1908. Grahamstown ...	Prof. G. E. Cory, M.A.	The History of the Eastern Province.
	A. Theiler, C.M.G.	Tropical and Sub-tropical Diseases of South Africa: their Causes and Propagation.
1909. Bloemfontein ...	C. F. Juritz, M.A., D.Sc., F.I.C.	Celestial Chemistry.
	W. Cullen.	Explosives: their Manufacture and Use.
Maseru ...	R. T. A. Innes, F.R.A.S., F.R.S.E.	Astronomy.
1910. Cape Town ...	Prof H. Bohle, M.I.E.E.	The Conquest of the Air.
1911. Bulawayo ...	J. Brown, M.D., C.M., F.R.C.S., L.R.C.S.E.	Electoral Reform—Proportional Representation.
	W. H. Logeman, M.A.	The Gyroscope.
1912. Port Elizabeth	A. W. Roberts, D.Sc., F.R.A.S., F.R.S.E.	Imperial Astronomy.
	Prof. E. J. Goddard, B.A., D.Sc.	Antarctica.
1913. Lourenço Marques	S. Seruya.	The History of Portuguese Conquest and Discovery.
1914. Kimberley ...	Prof. E. H. L. Schwarz, A.R.C.S., F.G.S.	The Kimberley Mines, their Discovery, and their relation to other Volcanic Vents in South Africa.
1915. Pretoria ...	E. T. Mellor, D.Sc., F.G.S., M.I.M.M.	The Gold-bearing Conglomerates of the Witwatersrand.
	C. W. Mally, M.Sc., F.E.S., F.L.S.	The House Fly under South African conditions.
1916. Maritzburg ...	C. P. Lounsbury, B.Sc., F.E.S.	Scale Insects and their travels.
Durban ...	R. T. A. Innes, F.R.A.S., F.R.S.E.	Astronomy.
1917. Stellenbosch ...	H. E. Wood, M.Sc., F.R.Met.S.	Some Unsolved Problems of Astronomy.
	Prof. J. D. F. Gilchrist, M.A., D.Sc., Ph.D., F.L.S., C.M.Z.S.	Some Marine Animals of South Africa.
1918. Johannesburg...	Prof. H. B. Fantham, M.A., D.Sc., A.R.C.S., F.Z.S.	Evolution and Mankind.
	Prof. J. E. Duerden, M.Sc., Ph.D., A.R.C.S.	Ostriches.
1919. Kingwilliamstown	Prof. E. J. Goddard, B.A., D.Sc	The Approaching South African Antarctic Expedition.
East London ...	Prof. G. E. Cory, M.A.	Early History of Kaffraria and East London.
1920. Bulawayo ...	Prof. J. A. Wilkinson, M.A., F.C.S.	The Nitrogen Problem.

MEETINGS AT BULAWAYO.

On *Wednesday, July* 14, 1920, at 11 a.m., the Association was officially welcomed by His Worship the Mayor of Bulawayo (Councillor Jas. Cowden) and the Borough Council in the Eveline School. Dr. I. B. Pole Evans (President) and Prof. J. A. Wilkinson (Vice-President) responded.

At 11.30 a.m., Mr. H. E. Wood, M.Sc., delivered an address, as President of Section A, on "Recent Progress in Astronomy." Mr. C. W. Mally, M.Sc., followed with an address, as President of Section D, on "Some Zoological Factors in the Economic Development of South Africa."

At 2 p.m., Members of the Association proceeded on motor trips to the Khami Ruins or to the Cement Works.

At 8.30 p.m., Dr. I. B. Pole Evans, M.A., F.L.S., President, delivered an address on "The Veld: Its Resources and Dangers," in the Grand Hotel, Mr. F. W. Mieleé presiding. (See page 1.)

The President subsequently presented the South Africa Medal to Professor E. Warren, D.Sc. (See page xxx.)

On *Thursday, July* 15, at 9.30 a.m., Mr. F. P. Mennell delivered an address, as President of Section B, on "Geology in Relation to Mining" in the Public Library. The Rev. H. A. Junod followed with an address, as President of Section E, on "The Magic Conception of Nature among Bantus."

Sectional Meetings took place in the afternoon.

At 8.30 p.m., Members attended a reception and conversazione, held by His Worship the Mayor, in the Grand Hotel.

On *Friday, July* 16, at 9.30 a.m., Dr. T. R. Sim delivered an address, as President of Section C, on "Causes leading toward Progressive Evolution of the Flora of South Africa."

At 11 a.m., Members proceeded by motor cars to the Matopos and World's View.

At 8.15 p.m., Prof. J. A. Wilkinson, M.A., gave a popular lecture on "The Nitrogen Problem," in the Public Library, the President of the Association presiding.

On *Saturday, July* 17, at 9.30 a.m., the Eighteenth Annual General Meeting was held in the Public Library, for Minutes of which see page xx.

At 11.30 a.m., Prof. R. A. Lehfeldt, B.A., D.Sc., delivered an address, as President of Section F, on "Labour Conditions in South Africa."

Sectional Meetings took place in the early afternoon.

At 4 p.m., His Honour the Administrator of Southern Rhodesia, Sir Drummond Chaplin, and Lady Chaplin gave a Garden Party to Members at Government House.

On the evening of Saturday, July 17, the Members proceeded to the Victoria Falls, and on Tuesday afternoon, July 20, attended a Garden Party kindly given by His Honour the Administrator of Northern Rhodesia, Sir Laurence Wallace, at the Government House, Livingstone.

OFFICERS OF LOCAL AND SECTIONAL COMMITTEES, BULAWAYO, 1920.

LOCAL COMMITTEE.

Chairman, W. F. Miolee: *Members*, G. Arnold, D.Sc., G. N. Blackshaw, B.Sc., Rev. H. Brown, C. Dixon, Rev. S. S. Dornan, B.A., H. B. Douslin, F. Eyles, E. V. Flack, Rev. E. Goetz, M.A., A. M. MacGregor, B.A., H. B. Maufe, B.A., F. P. Mennell, A. J. C. Molyneux, G. A. Pingstone, Mr. Justice Russell, B.A., LL.B., J. W. Sly, Dr. E. H. Strong, N. H. Wilson, A. R. Welsh; *Local Secretary*, D. Niven.

RECEPTION COMMITTEE.

His Worship the Mayor, Councillor James Cowden (*Chairman*), D. Niven (*Secretary*), Councillors C. Dixon, H. R. Barbour, W. J. Bickle, J. H. Bookless, H. B. Ellenbogen, C. T. Eriksson, H. C. Fletcher, Dr. S. L. J. Steggall, F. Fitch (*Town Clerk*), Dr. G. Arnold, R. Aserman, W. J. Atterbury, J. H. Ayling, F. R. Barnes, E. Basch, Col. C. F. Birney, Lieut.-Col. J. Brady, G. N. Blackshaw, W. A. Caton, W. A. Carter, N. H. Chataway, H. A. Cloete, Sir Charles Coghlan M.L.C., J. C. Coghlan, Rev. M. I. Cohen, A. J. Cole, Major J. C. Jesser Coope, C. E. G. Cumings, W. Cunningham, A. J. Davies, C. Davis, E. B. de Beer, H. A. de Beer, Rev. S. S. Dornan, W. E. Dowsett, Major C. Duly, Dr. Eaton, F. Eyles, F. Fisher, E. V. Flack, C. D. Fleming, P. Fletcher, R. A. Fletcher, M.L.C., L. R. Forbes, Dr. A. F. Forrester, G. Fortune, A. Fraser, A. M. Fraser, Rev. E. Goetz, N. Griffin, H. T. Guerrier, F. L. Hadfield, M.L.C., A. Harrington, A. G. Hay, Capt. A. G. Hendrie, Capt. Bryce Hendrie, Sir Melville Heyman, Capt. W. C. Hoaten, G. R. Holgate, H. S. Hopkins, Rev. Horn, Advocate Hudson, H. M. Huntley, J. Hynd, F. Issels, H. M. G. Jackson, A. Jacobs, Rev. Johanny, Lieut.-Col. D. Judson, G. G. Kempster, Rev. Kendal, G. H. Laidman, L. Landau, H. T. Longden, H. T. Low, J. G. Macdonald, O.B.E., D. MacGillivray, A. M. Macgregor, F. A. Mallett, Dr. MacLaren, H. B. Maufe, T. Meikle, F. P. Mennell, W.F . Miolee, A. H. Mitchell, A. J. C. Molyneux, R. M. Nairn, C. H. Pead, G. A. Pingstone, L. G. Puzey, A. C. Raymer, S. Redrup, Major Robertson, C. Rodney, Mr. Justice Russell, F. Scott, J. W. Sly, T. Beach Smith, Rev. J. Stanlake, G. Stewart, Dr. E. H. Strong, G. Sutherland, P. H. Taylor, H. B. Thomas, Lieut.-Col. A. Tomlinson, Dr. A. Vigne, Lieut.-Col. A. C. L. Webb, F. L. Walkden, A. R. Welsh, Dr. S. White, N. H. Wilson, C. F. de B. Winslow, Rev. J. P. Young.

SECTIONAL COMMITTEES.

Section A.—ASTRONOMY, MATHEMATICS, PHYSICS, METEOROLOGY, GEODESY, SURVEYING, ENGINEERING, ARCHITECTURE AND IRRIGATION.

President, H. E. Wood, M.Sc., F.R.Met.S., F.R.A.S.; *Vice-Presidents*, Rev. E. Goetz, M.A., F.R.A.S., J. Lunt, D.Sc.; *Members*, Sir J. C. Beattie, D.Sc., F.R.S.E., Prof. A. Brown, M.A., B.Sc., Percy Cazalet, M.I.M.M., Prof. L. Crawford, M.A., D.Sc., F.R.S.E., Prof. A. E. du Toit, M.A., Prof. P. G. Gundry, B.Sc., Ph.D., A.R.C.S., C. J. Gyde, A.M.I.C.E., W. Ingham, M.I.C.E., M.I.M.E., R. T. A. Innes, F.R.A.S., F.R.S.E., D. Judson, M.I.E.E., F. E. Kanthack, C.M.G., M.I.C.E., M.I.M.E., S. de J. Lenfesty, M.A., W. F. Miolee, Prof. J. T. Morrison, M.A., B.Sc., F.R.S.E., N. Mudd, M.A., Prof. A. Ogg, M.A., B.Sc., Ph.D., A. H. Reid, F.R.I.B.A., A. W. Roberts, D.Sc., F.R.A.S., F.R.S.E.; *Recorder*, Prof. J. Orr, O.B.E., B.Sc., M.I.C.E.; *Hon. Secretary*, A. C. Jennings, A.M.I.C.E.

Section B.—CHEMISTRY, GEOLOGY, METALLURGY, MINERALOGY AND GEOGRAPHY.

President, F. P. Mennell, F.G.S., M.I.M.M.; *Vice-Presidents*, G. N. Blackshaw, O.B.E., B.Sc., F.C.S., Prof. R. B. Denison, D.Sc.; *Members*, Prof. E. Anderson, B.Sc., Ph.D., Clement Dixon, M.I.M.M., Jas Gray, F.I.C., H. H. Green, D.Sc., F.C.S., C. F. Juritz, M.A., D.Sc., F.I.C., E. T. Mellor, D.Sc., F.G.S., J. McCrae, Ph.D., F.I.C., J. Moir, M.A., D.Sc., F.I.C., B. de C. Marchand, B.A., D.Sc., Prof. D. F. du T. Malherbe, M.A., Ph.D., A. J. C. Molyneux, F.G.S., G. A. Pingstone, F.C.S., Prof. M. M. Rindl, Ing.D., Prof. E. H. L. Schwarz, A.R.C.S., F.G.S., Prof. H. Tietz, M.A., Ph.D., Prof. B. de S. J. van der Riet, M.A., Ph.D., P. A. Wagner, Ing.D., B.Sc., Prof. J. A. Wilkinson, M.A., F.C.S., Prof. A. Young, M.A., D.Sc.; *Recorder*, J. H. Hutcheon, M.A., F.R.S.G.S.; *Hon. Secretary*, A. M. Macgregor, B.A., F.G.S.

Section C.—BOTANY, BACTERIOLOGY, AGRICULTURE AND FORESTRY.

President, T. R. Sim, D.Sc.; *Vice-Presidents*, E. A. Nobbs, Ph.D., Prof. D. Thoday, M.A.; *Members*, Prof. A. M. Bosman, B.Sc., Prof. R. H. Compton, M.A., Miss E. M. Doidge, M.A., D.Sc., F.L.S., Miss A. V. Duthie, M.A., F. Eyles, F.L.S., E. Holmes-Smith, B.Sc., Miss M. Heatley, M.A., R. A. Fletcher, Prof. J. M. Hector, B.Sc., C. E. Legat, B.Sc., Prof. C. E. Moss, M.A., D.Sc., F.L.S., G. H. Mundy, F.L.S., Prof. G. Potts, M.Sc., Ph.D., Prof. A. I. Perold, B.A., Ph.D., Ven. Archdeacon F. A. Rogers, M.A., Mrs. Russell, B.A., Prof. S. Schonland, M.A., Ph.D., F.L.S.; *Recorder*, E. P. Phillips, M.A., D.Sc.; *Hon. Secretary*, Prof. H. A. Wager, A.R.C.S.

Section D.—ZOOLOGY, PHYSIOLOGY, HYGIENE AND SANITARY SCIENCE.

President, C. W. Mally, M.Sc., F.E.S.; *Vice-Presidents*, G. Arnold, D.Sc., F.E.S., A. J. Orenstein, M.D.; *Members*, H. G. Breijer, Ph.D., A. G. Brinton, F.R.C.S., L.R.C.P., Prof. E. H. Cluver, B.A., M.B., B.Ch., Prof. T. F. Dreyer, B.A., Ph.D., Prof. H. B. Fantham, M.A., D.Sc., F.Z.S., Prof. E. J. Goddard, B.A., D.Sc., Prof. J. D. F. Gilchrist, M.A., D.Sc., Ph.D., F.L.S., J. Hewitt, B.A., W. M. Hewetson, M.B., D.P.H., A. K. Haagner, F.Z.S., A. J. T. Janse, F.E.S., C. P. Lounsbury, B.Sc., F.E.S., Sir F. Spencer Lister, M.R.C.S., L.R.C.P., D. T. Mitchell, M.R.C.V.S., H. U. Moffatt, M.L.C., Sir Arnold Theiler, K.C.M.G., D.Sc., E. H. Strong, M.R.C.S., L.R.C.P., W. Watkins-Pitchford, M.D., F.R.C.S., D.P.H., Miss M. Wilman; *Recorder*, Annie Porter, D.Sc., F.L.S.; *Hon. Secretary*, P. H. Taylor.

Section E.—ANTHROPOLOGY, ETHNOLOGY, NATIVE EDUCATION, PHILOLOGY AND NATIVE SOCIOLOGY.

President, Rev. Henri A. Junod; *Vice-Presidents*, Mr. Justice A. F. Russell, B.A., LL.B.; Principal A. Kerr; *Members*, Rev. S. G. Gilkes Aitchison, M.A., D.D., Rev. S. S. Dornan, M.A., Prof. C. M. Drennan, M.A., Rev. G. Evans, Rev. J. R. L. Kingon, M.A., F.R.S.E., H. S. Keigwin, M.A., J. McLaren, Prof. Morgan Watkin, M.A., L. es L., Ph.D., Rev. E. W. H. Musselwhite, B.A., Prof. R. D. Nauta, Rev. W. A. Norton, M.A., B. Litt., Rev. Noel Roberts, S. Seruya; *Recorder*, N. H. Wilson; *Hon. Secretary*, Rev. Neville Jones.

Section F.—EDUCATION, HISTORY, MENTAL SCIENCE, PRACTICAL ECONOMY, GENERAL SOCIOLOGY AND STATISTICS.

President, Prof. R. A. Lehfeldt, B.A., D.Sc.; *Vice-Presidents*, Sir Francis Newton, K.C.M.G., Prof. O. Waterhouse, M.A.; *Members*, J. E. Adamson, M.A., A. Aiken, E. Chappell, C.B.E., Prof. J. Clark, M.A., LL.D., G. Duthie, M.A., F.R.S.E., S. Evans, J. A. Foote, F.G.S., F.E.I.S., Prof. T. M. Forsyth, M.A., Ph.D., Prof. J. H. Hofmeyr, M.A., Prof. W. S. Johnson, M.A., J. W. Jagger, F.S.S., M.L.A., G. T. Morice, K.C., Prof. R. Leslie, M.A., F.S.S., Prof. W. A. Macfadyen, M.A., LL.D., Miss B. Stoneman, D.Sc., A. J. Somerville, M.A., H. A. Trubshaw, A. R. Welsh; *Recorder*, J. Mitchell; *Hon. Secretary*, B. M. Narbeth, B.Sc.

PROCEEDINGS OF THE EIGHTEENTH ANNUAL GENERAL MEETING OF MEMBERS.

(Held in the Board Room, Library Buildings, Bulawayo, on Saturday, July 17, 1920, at 9.30 a.m.)

PRESENT: Dr. I. B. Pole Evans (President), in the chair, C. L. Andrew, Miss D. Ball, Miss A. M. Bottomley, G. F. Britten, Rev. Holman Brown, S. N. C. Collins, Dr. E. M. Delf, Prof. R. B. Denison, F. Eyles, Prof. H. B. Fantham, E. Farrar, J. A. Foote, D. F. Forsyth, Miss Forsyth, Mrs. Gibson, Father E. Goetz, Dr. H. H. Green, C. J. Gray, L. C. Grice, Prof. P. Gundry, J. S. Henkel, Rev. H. A. Junod, E. J. Laschinger, Prof. W. A. Macfadyen, A. M. Macgregor, A. S. McIntyre, Mrs. H. M. McKay, C. W. Mally, Mrs. A. W. Marchand, Dr. B. de C. Marchand, H. B. Maufe, Dr. A. Mavrogordato, W. F. Miolee, A. J. C. Molyneux, Advocate G. T. Morice, H. G. Munday, B. M. Narbeth, Prof. E. Newberry, Dr. E. A. Nobbs, Dr. A. J. Orenstein, Prof. A. C. Paterson, Prof. H. H. Paine, Miss A. Robinson, Dr. A. W. Rogers, Ven. Archdeacon F. A. Rogers, Prof. W N. Roseveare, Prof. I. J. Rousseau, Miss M. Roux, J. Sandground, Dr. T. R. Sim, S. H. Skaife, Miss E. C. Steedman, D. P. Suttie, Prof. D. Thoday, Mrs. M. G. Thoday, Miss M. Thomson, Prof. H. J. W. Tillyard, Dr. P. A. van der Bijl, G. Weeks, Prof. J. A. Wilkinson, Miss M. Wilman, N. H. Wilson, H. E. Wood, Prof. A. W. Young and M. K. Carpenter (Assistant General Secretary).

MINUTES.—The Minutes of the Seventeenth Annual General Meeting, held at Kingwilliamstown on July 9, 1919, and printed on pp. xxiv-xxviii of the Report of the Kingwilliamstown Session (vol. xvi of the JOURNAL), were confirmed.

ANNUAL REPORT OF THE COUNCIL.—The Annual Report of the Council for the year 1919-20, which had been open for inspection by Members in the Registration Room at the Eveline School, was, on the proposal of Prof. D. Thoday, seconded by Mr. Fred Eyles, taken as read and adopted. This Report will be found on p. xxiii of this issue.

FINANCIAL STATEMENT AND BALANCE SHEET FOR THE YEAR 1919-1920.—This Statement and Balance Sheet having been suspended for inspection by the side of the Annual Report of Council, Prof. J. A. Wilkinson moved that the same be passed, subject to audit. This was seconded by Prof. D. Thoday and agreed to. (See pp. xxvi-xxix.)

HOUSING OF SCIENTIFIC AND TECHNICAL SOCIETIES.—Prof. J. A. Wilkinson, on behalf of Prof. J. Orr, moved the following motion, standing in the name of the latter:—

"That a part of the Trust Funds of this Association be invested with the 'Associated Scientific and Technical Societies of South Africa.'"

In speaking to the motion, the mover outlined the scheme whereby the Scientific and Technical Societies on the Rand had provided themselves with a permanent home. He enlarged upon the advantages which would accrue to the Association by becoming a participating body, the minimising and centralisation of secretarial work, the provision of rest, committee and lecture rooms, of a reading-room containing the latest scientific and technical literature, and of facilities for meeting our own members as well as the members of other societies. Furthermore, this Association, by becoming a participating body, would not only gain in standing, but would materially assist in the co-operative movement amongst scientific societies, and thus prevent much overlapping in expense.

Dr. A. J. Orenstein, in seconding the motion, dwelt upon the benefits members would derive, both individually and collectively, by the Association becoming one of the foundation members of the scheme.

Dr. E. Nobbs, Mr. C. W. Mally and Prof. W. A. Macfadyen asked questions respecting the soundness of the scheme and whether the proposition was such as should be submitted to the Trustees for their consideration.

After these queries had been answered in the affirmative by Prof. Wilkinson, Mr. Laschinger and Dr. Orenstein, it was agreed that the Association should become a participating body, and the following amendment was proposed by Prof. Macfadyen:—

"That in the event of debentures being raised to take the place of the first mortgage, the Trustees be authorised and recommended to invest £500 of their Trust Funds in that form."

This was seconded by Mr. C. W. Mally.

Prof. J. A. Wilkinson thereupon withdrew the original motion and the amendment became the substantive motion before the meeting, and was agreed to unanimously.

ELECTION OF OFFICERS FOR THE YEAR 1920-1921.—The following Officers were elected: *President*, Prof. J. E. Duerden, M.Sc., Ph.D., A.R.C.S.; *Vice-Presidents*, Prof. G. E. Cory, M.A., Prof. R. Leslie, M.A., F.S.S., T. R. Sim, D.Sc., Prof. J. A. Wilkinson, M.A., F.C.S.; *Hon. General Secretaries*, H. E. Wood, M.Sc., F.R.Met.S., F.R.A.S., C. F. Juritz, M.A., D.Sc., F.I.C.; *Hon. General Treasurer*, J. A. Foote, F.G.S., F.E.I.S.; *Hon. Editor of Publications*, Prof. H. B. Fantham, M.A., D.Sc., F.Z.S.

ELECTION OF COUNCIL MEMBERS FOR 1920-1921.—The following were elected Members of Council for the year 1920-1921, the retiring President Dr. I. B. Pole Evans, being also *ex officio* a Member of Council for the year:—

I. CAPE PROVINCE.—(1) *Cape Peninsula:* Prof. L. Crawford, M.A., D.Sc., F.R.S.E., Dr. O. J. Currie, M.B., M.R.C.S., Rev. W. Flint, D.D., J. Lunt, D.Sc., F.I.C., C. W. Mally, M.Sc., F.E.S., A. H. Reid, F.R.I.B.A., Prof. D. Thoday, M.A. (2) *East London:* E. Hill, M.R.C.S., L.R.C.P., D.P.H. (3) *Kimberley:* Miss M. Wilman. (4) *Kingwilliamstown:* E. B. Dwyer, B.A., J. Leighton, F.R.H.S. (5) *Port Elizabeth:* Rev. J. R. L. Kingon, M.A., F.R.S.E. (6) *Stellenbosch:* Prof. E. J. Goddard, B.A., D.Sc., Miss Alta Johnson, Ph.D.

II. TRANSVAAL.—(1) *Witwatersrand:* C. Aburrow, M.I.C.E., M.S.A., N. O. Curry, J. H. Dobson, D.S.O., M.Sc., E. Farrar, J. Gray, F.I.C., J. A. Foote, F.G.S., F.E.I.S., W. Ingham, M.I.C.E., M.I.M.E., R. T. A. Innes, F.R.A.S., F.R.S.E., J. McCrae, Ph.D., F.I.C., E. T. Mellor, D.Sc., M.I.M.M., F.G.S., J. Mitchell, J. Moir, M.A., D.Sc., F.I.C., Prof. J. Orr, O.B.E., B.Sc., Annie Porter, D.Sc., F.L.S., W. Reid, F.R.I.B.A., (2) *Pretoria:* Ethel M. Doidge, M.A., D.Sc., F.L.S., B. de C. Marchand, B.A., D.Sc., E. P. Phillips, M.A., D.Sc., Sir Arnold Theiler, K.C.M.G., D.Sc.

III. ORANGE FREE STATE.—Prof. T. F. Dreyer, B.A., Ph.D., F. W. Storey, B.Sc., F.C.S.

IV. NATAL.—(1) *Durban:* J. Kirkman, J.P., B. M. Narbeth, B.Sc. (2) *Pietermaritzburg:* Prof. J. W. Bews, M.A., D.Sc., Prof. E. Warren, D.Sc.

V. RHODESIA.—(1) *Bulawayo:* Rev. E. Goetz, S.J. (2) *Salisbury:* H. B. Maufe, B.A., F.G.S.

VI. MOZAMBIQUE.—S. Seruya.

There are still a few vacancies, and elections to fill them will be made by the Council.

CREATION OF OFFICE OF HONORARY LIBRARIAN.—Prof. J. A. Wilkinson moved in accordance with notice, that a new office of Honorary Librarian be created, that the person elected be given a seat on the Council, and that the Constitution be altered accordingly. If Members decided on this course, he further proposed that Dr. Annie Porter, D.Sc., F.L.S., be appointed Honorary Librarian. Dr. Porter, at the request of the Council, had been in charge of the Association's Library for some months past.

The motion was seconded by Mrs. Thoday, supported by Prof. Macfadyen, and carried unanimously.

ANNUAL SESSION, 1921.—Dr. I. B. Pole Evans stated that an invitation had been received from the Mayor of Durban, through Mr. B. M.

Narbeth, for the Association to hold its Annual General Meeting in 1921 at that city, and he proposed that the invitation be accepted.

This was agreed to unanimously.

PRESIDENT, 1922.—Dr. I. B. Pole Evans proposed that Dr. A. W. Rogers, M.A., F.R.S., be asked to accept the Presidency of the Association for the year 1922. This was agreed to unanimously, and Dr. Rogers accepted.

PROPOSED INCREASE OF ANNUAL SUBSCRIPTION.—In the absence of Prof. C. E. Moss, and for the purpose of discussion, Prof. J. A. Wilkinson proposed that the meeting now proceed to consider the advisability of increasing the annual subscription to 30s.

Mr. E. J. Laschinger seconded the proposal.

Prof. H. B. Fantham emphasised the need of more funds for the publication of the JOURNAL on account of the increased cost of materials and labour. The JOURNAL during the coming year would cost at least £1,000, probably £1,200.

Mr. B. M. Narbeth strongly opposed any increase in the annual subscription on the ground that it would restrict the activities of the Association by a reduction in the number of Members. He was of the opinion that the additional money required to meet the cost of the JOURNAL could be raised by other means.

Dr. A. W. Rogers hoped that the JOURNAL, which served a very useful purpose in disseminating scientific knowledge, would not be greatly reduced or curtailed on account of the lack of funds.

The question of printing advertisements with the JOURNAL was mentioned as a possible source of revenue, but it seemed to be considered by some Members that little profit would accrue after paying commission and printing, unless a large number of advertisements could be obtained.

The possibility of increasing the annual subscription to 25s. was also discussed.

Dr. A. J. Orenstein proposed that, in view of the increased cost of the JOURNAL, the matter be referred to the new Council for consideration and definite action, if this were constitutional.

Mr. H. E. Wood seconded this motion, which was carried.

In the course of the discussion, Miss Steedman suggested that the Government be approached for an increased grant. Mr. F. Eyles suggested that the Rhodesian Government be also approached for a grant towards the expense of publishing the JOURNAL. Mrs. Thoday recommended that agriculturalists and machinery merchants be approached for donations for this purpose.

The meeting agreed that these recommendations be referred to the Council.

WIRELESS TELEGRAPHY.—Mr. H. E. Wood submitted the following motion:—

"That the Government be requested to erect forthwith a wireless telegraph station of sufficient power to receive and transmit messages to Europe and North America, and that copies of this resolution be sent to the Prime Minister, the Minister for Industries and the Daily Press."

This was agreed to unanimously.

VOTES OF THANKS.—On the motion of Mr. C. W. Mally, it was unanimously resolved that the hearty thanks of the Association should be accorded to:—

(1) The Administrator and Lady Chaplin for their kindly interest in the Association and for the Garden Party given in honour of its Members.

(2) His Worship the Mayor and Town Council and Citizens of Bulawayo for their cordial welcome to the Association, for the evening reception, and for the general facilities afforded to the Members.

(3) The members of the Local Reception Committee for their excellent arrangements for the meeting and for their untiring efforts on behalf of every visiting Member of the Association.

(4) The Ladies of Bulawayo for their kind hospitality in providing tea.

(5) The Governing Bodies or Committees of many local institutions, especially the Bulawayo Club, the Eveline School, the Public Library and the St. George's School.

(6) All those who provided transport for the excursions to the Khami Ruins, the Cement Works and the World's View

(7) The Boy Scouts for many favours to members.

(8) The Press for their efforts in bringing the work of the Association prominently before the public.

(9) Mr. D. Niven, Secretary to the Reception Committee, for his kindly activities in preparation for and during the visit of the Association.

A hearty vote of thanks was unanimously accorded the retiring President, Dr. I. B. Pole Evans, for his services during the past year.

REPORT OF THE COUNCIL FOR THE YEAR ENDING 30TH JUNE, 1920.

1. OBITUARY : Your Council has to report, with great regret, the deaths of the following members :—Sir Hamilton Goold-Adams, G.C.M.G., President of the Association 1909; Mr. Maurice S. Evans, C.M.G., President of Section D in 1916; the Hon. Justice Jackson, who has taken a deep interest in the Association for several years and was nominated as President of Section E this year; also Mr. Jas. Bisset; the Rev. Jas. Campbell; Dr. J. M. Coutts; Dr. J. Schlesinger Delmore; Mr. H. G. Flanagan, F.L.S.; Mr. Hennen Jennings; Mr. C. D. Leslie; Senator the Hon. S. Marks and Mr. F. S. Watermeyer.

2. MEMBERSHIP : Since the last report 143 new members have joined the Association, 10 have died, and 14 have been removed from the register by resignation or by resolution of the Council. The nett increase in membership has therefore been 119.

The following comparative table, as from the 1st July in each year, shows the various Provinces from which members are drawn :—

	1919.	1920.
Transvaal	410	474
Cape Province	281	294
Orange Free State	40	45
Natal	82	92
Rhodesia	17	43
Mozambique	9	10
South-West Africa Protectorate	1	1
Abroad	21	21
Unknown	2	2
	863	982

3. CHANGE OF HEADQUARTERS : In accordance with the resolution passed at the Annual General Meeting of members at Kingwilliamstown last year, the Headquarters of the Association were removed to Johannesburg. Office and Library accommodation was generously provided by the administration of the Public Library in their building, which is centrally situated in Kerk Street, at the nominal rental of £2 10s. per month, and your Council desires to place on record its gratitude for this benefaction.

4. THE JOURNAL : Unfortunately, the publication of Volume XV. of the Johannesburg 1918 Meeting, was not completed until the end of November, 1919. Under the Editorship of Dr. Juritz, the first number of Volume XVI., containing papers read at the Kingwilliamstown 1919 Meeting, was published at the beginning of January, 1920, and the second number of that volume at the beginning of April, 1920. Dr. Juritz at this time resigned the Editorship, and the thanks of the Council were tendered to him for his

services. The duties of Editor were undertaken by Dr. H. B. Fantham. A third number of Volume XVI. appeared at the end of April, under the designation of October-December, 1919. A fourth number called January-March, 1920, did not appear until the end of June, owing to a month's delay in the printer's office, after the page proofs were passed. At the present time, the galley proofs of the remaining Kingwilliamstown papers, to form an April-July, 1920, number, are being corrected. Owing to the great delay, it has been found impracticable to submit galley proofs of the forthcoming issue to some of the authors, though this step was taken with great reluctance. An index is in preparation.

In view of the high cost of printing and the paper shortage, it is strongly recommended that either an annual volume be issued or quarterly numbers. It is intended to endeavour to secure advertisements, but commission will probably have to be paid to obtain them, and the cost of printing them will be heavy. Even with the aid of advertisements, in view of the increased cost of postage, the Editor is unable to recommend for the present the continuance of monthly parts, which have nearly always been behind their date of publication; further, such irregular publication does not commend itself to advertisers. Money could also be saved by condensing or omitting some of the matter usually printed at the beginning of a new volume.

5. Library: The Library, as received from Capetown, was unfortunately not in a satisfactory condition. The Journals were not arranged, nor was it possible to find some of the books and periodicals listed. On the other hand, a large bulk of old correspondence and circulars of meetings held many years ago, was received. An enormous weight, amounting to several tons, of the Journals of the Association, both bound volumes and separate monthly parts, was also received. It would appear that far too many copies of the Journal were printed in the past, except in the case of the Meetings of 1908 and 1909. This collection of old papers and the excess number of Science Journals involved the Association in much needless expense for removal, and they are occupying space in the Library which could be more usefully filled by journals and publications obtained in exchange. Attempts are being made to utilise this excess of old literature of the Association in obtaining further exchanges, but in these days of costly printing and a world shortage of paper, it is very difficult to obtain new exchanges.

It appears that little has been done in the way of binding volumes in the Association's Library for a long time past, and loose numbers are deteriorating and getting lost. Money is urgently needed for binding.

6. Assistant General Secretary: Owing to the change of Headquarters of the Association from Capetown to Johannesburg, as decided by the resolution passed at the Annual General Meeting of members held at Kingwilliamstown, the post of Assistant General Secretary became vacant by the resignation of Mr. J. P. Starke, who had held the office since the resignation of Mr. H. Tucker, mentioned in last year's report. The Council decided to advertise the post, and as a result Mr. M. K. Carpenter was chosen out of 108 applicants, and he took up the duties of the post on 1st September, 1919.

7. Affiliation to British Association: No reply has yet been received regarding this matter mentioned in last year's report.

8. Donations: The thanks of the Association are due to the Hon. The Minister of Mines and Industries for the renewal of the grant of £150 for the year ending 30th June, 1919, towards defraying the expenses of publishing the Association's Journal, and £50 in aid of the expenses incurred in connection with the Annual General Meeting. A further grant of £250 was made for the year ending June, 1920, of which £150 has already been received. In addition to the above, your Council is pleased to be able to record its thanks to the Witwatersrand Council of Education for a grant of £100, and to Mr. W. Ingham for a donation of £50 towards defraying the expenses of removal of the library from Capetown to Johannesburg.

9. South Africa Medal and Grant, 1920: On the recommendation of the South Africa Medal Committee consisting of Professor H. B. Fantham (Chairman), Sir Arnold Theiler, Principal Sir Carruthers Beattie, Professor L. Crawford, Dr. I. B. Pole-Evans, Dr. H. H. Green, Professor R. Leslie.

Mr. C. P. Lounsbury, Professor J. Orr, Dr. Annie Porter, Dr. A. W. Roberts and Professor J. A. Wilkinson, your Council has awarded the South Africa Medal, together with a grant of £50, to Professor Ernest Warren, D.Sc., F.Z.S., Director of the Natal Museum, Pietermaritzburg, and Professor of Zoology in the Natal University College (see p. xxx).

10. Closer Union and Joint Housing of Learned Societies: It is gratifying to be able to report that the scheme, the principle of which was approved by members at the last Annual General Meeting, has attained fruition, a suitable building in Johannesburg having been secured by the generosity of the Transvaal Chamber of Mines for this purpose. As resolved, Professors Orr and Watkin represented this Association on the Committee dealing with this question, and it is hoped that the Association will become a foundation member. This matter, which is of great importance, will be discussed at the Annual General Meeting of members.

11. Zoological Survey: With respect to the resolutions mentioned in last year's report, a conference on this matter was held in Pretoria in January, representatives of the Universities, Museums, and Government Scientific Departments of the Union and Rhodesia being present at the invitation of the Hon. The Minister of Mines and Industries, who opened the proceedings. Dr. Gilchrist was elected Chairman, and the report of the conference was, by the Minister's request, forwarded to the Advisory Board of Industries and Science, which has not yet reported. Your Council feels that the time has now arrived to take further steps in this matter.

12. Reconstruction of the Union Senate: Messrs. R. T. A. Innes and J. A. Foote were appointed a committee to communicate to the Press an article embodying the whole course of action taken by the Association concerning the constitution of the Senate, from the inception of the idea by Mr. Watkins, of Kimberley, up to the present.

13. International Research Council: As no steps had been taken by any Institution of Learned Societies in the Union to collaborate with the International Research Council formed in Europe for the international co-operation and promotion of research, your Council resolved that the Government of the Union be recommended to become a member of this International Council, and that the Association be grouped with it. A copy of this resolution was addressed to the Hon. The Minister of Education, but so far no reply has been received.

14. The New Council: On the basis of membership provided for in the Constitution of the Association, Section VI. (d), the number of members of Council assigned for the representation of each centre during the ensuing twelve months should be distributed as follows:—

Cape Province:	
Cape Peninsula	7
East London	1
Kimberley	2
Kingwilliamstown	1
Port Elizabeth	2
Stellenbosch	2
Transvaal:	
Witwatersrand	17
Pretoria	4
Potchefstroom	1
Transvaal Outside	1
Orange Free State:	
Bloemfontein	2
Natal:	
Maritzburg	2
Durban	2
Natal Outside	1
Rhodesia:	
Bulawayo	1
Salisbury	1
Mozambique	1
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REPORT OF THE HONORARY TREASURER FOR THE YEAR ENDING MAY 31, 1920.

In view of the serious nature of the finances of the Association, the Council has requested me to place the following facts before the members.

The only really permanent and regular source of income which the Association possesses is that which is derived from members' annual subscriptions. At present these amount to about £900.

The chief item of expenditure is that of printing and publishing the JOURNAL. If the JOURNAL had appeared regularly once per month, the cost this year would have been at least £1,200.

The cost of paper, of printing, of producing illustrations, and of binding has increased enormously of late; and there is no prospect of any marked reduction coming about for some time to come. On the contrary, there is every likelihood of further increases.

The Government has recently increased its postal letter charges by 50 per cent., and this entails more office expenses.

The Council recently appointed a sub-committee to consider the almost precarious condition of the finances of the Association, and the following methods of reducing expenditure and of increasing revenue were considered:—

1. *Reducing the Size of the* JOURNAL.—It was felt that to reduce the size of the JOURNAL at present would be a questionable policy, as the JOURNAL represents the best means of retaining our present members and of attracting new members.

2. *Inserting Advertisements in the* JOURNAL.—It was decided to endeavour to obtain advertisements for insertion in the JOURNAL as soon as regular issues could be guaranteed, and it was hoped that this could be done next year.

3. *Increasing the Number of Members.*—All members of Council were specially urged to do their utmost to obtain new members. The result of this appeal, however, has not been so satisfactory as it might have been.

4. *Securing an Increased Grant from the Government.*—The Minister of Education was approached, and, as a result, the Government's grant to the Association has been increased from £150 to £250.

5. *Obtaining Private Donations.*—The amount secured under this heading now amounts to £175.

6. *Increasing the Amount Payable by Life Members.*—The consideration of this matter was left over for the present, but the matter should be considered at an early date, as the payments made now by life members are much too low.

7. *Increasing the Annual Subscription.*—After much discussion, the Council felt they had no other course open to them than to request the members at the Annual General Meeting, to be held at Bulawayo in July next, to agree to an increase in the annual subscription from twenty to thirty shillings.

It should be mentioned that other Societies (*e.g.*, the British Association for the Advancement of Science, the Linnean Society of London, and the British Ecological Society) have already found it necessary to increase their annual subscription. In addition, the Linnean Society has, for the present, ceased to issue its Transactions. Other Societies (*e.g.*, the Royal Geographical Society) have reduced the size of their Journals. Economies have been effected in connection with most Journals unconnected with Societies, or the price of such Journals has been increased.

The above-mentioned Societies were self-supporting before the cost of labour and of commodities generally reached their present high level, and it is even more essential for our Association, which is not self-supporting, to consider, and to consider seriously, how it can reduce its expenses and augment its income.

C. E. MOSS,

Hon. General Treasurer.

June 25, 1920.

THE SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

BALANCE SHEET, AS AT 31st MAY, 1920.

Liabilities.

To Sundry Creditors		£603 12 2
Library Deposit	£3 0 0	
Subscriptions paid in advance ...	61 0 0	
Associate Members (Bulawayo Meeting)	9 10 0	
Townshend, Taylor & Snashall (printing Journal)	527 2 2	
,, South African Medal Fund ...		1,500 14 6
,, Endowment Fund		1,670 0 0
		£3,771 6 8

Assets.

By Cash		£412 6 6
Cape of Good Hope Savings Bank Deposit, with accrued interest ...	£315 10 0	
At Bank and in Hand	96 16 6	
,, Witwatersrand Council of Education For Donation, since paid.		100 0 0
,, Furniture		28 16 2
,, Trustees, South African Medal Fund		1,500 14 6
,, Trustees, Endowment Fund ...		1,573 0 0
,, Revenue and Expenditure Account ...		159 9 6
Excess of Expenditure over Revenue for the year	£489 8 2	
Less Credit Balance at 31st May, 1919	329 18 8	
		£3,774 6 8

C. E. MOSS, *Hon. Gen. Treasurer.*

We have examined the Books and Vouchers of the Association for the year ended 31st May, 1920, and certify that, in our opinion, the above Balance Sheet correctly sets forth the position of the affairs of the Association at the 31st May, 1920, according to the best of our information and the explanations given us and as shown by the Books.

ALEX. AIKEN & CARTER, *Auditors.*

Johannesburg,

29th October, 1920.

THE SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

SOUTH AFRICA MEDAL FUND ACCOUNT FOR THE YEAR ENDED 31st MAY, 1920.

To Balance, 31st May, 1920	£1,500 11 6	By Balance, 31st May, 1919 ...	£1,115 13 8
		,, Interest received during year	55 0 10
	£1,500 11 6		£1,500 11 6

NOTE. The award to Prof. E. Warren has not yet been made.

ENDOWMENT FUND ACCOUNT FOR THE YEAR ENDED 31st MAY, 1920.

To Interest transferred to General Account ..	£69 10 0	By Balance, 31st May, 1919 ...	£1,573 0 0
,, Balance, 31st May, 1920	1,670 0 0	,, Life Membership Subscriptions ..	97 0 0
		,, Interest received during year	69 10 0
	£1,739 10 0		£1,739 10 0

NOTE. The Life Membership Subscriptions received for the year have not yet been paid over to the Trustees for the Fund.

THE SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

REVENUE AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31ST MAY, 1920.

To Assistant Secretary's Salary ...			£120 0 0
,, Rent			28 10 0
,, JOURNAL Expenses		£1,068 3 8	
Less—Sales and Reprints ...		26 8 6	
		1,041 15 2	
Less—Donation: Department of Education		150 0 0	
			891 15 2
,, Printing and Stationery ...			37 15 9
,, Stamps and Telegrams			23 12 1
,, Audit Fees, 1918-1919			5 5 0
,, Sundry General Expenses ...			31 0 8
,, Grant under Rule IX			18 1 6
,, Annual Meeting Expenses ...			19 16 10
,, Depreciation on Furniture ...			3 2 0
			1,181 19 0
,, Removal of Library—			
Packing and Forwarding ...		113 8 0	
Fixing Library, *less* £1 transferred to Furniture Account ...		71 13 8	
		215 1 8	
Less—Sale of Cases		10 2 6	
		204 19 2	
Less—Donations—			
W. Ingham ...	£50 0 0		
Witwatersrand Council of Education ...	100 0 0		
		150 0 0	
			54 19 2
			£1,236 18 2

By Annual Subscriptions	£602 0 0
,, Arrear Subscriptions	61 0 0
,, Interest on Endowment Fund	69 10 0
,, Interest on Savings Bank Deposit (estimated)	15 0 0
,, Balance, being Excess of Expenditure over Revenue for the year	489 8 2
	£1,236 18 2

Johannesburg,
29th October, 1920.

Examined and found correct.
ALEX. AIKEN & CARTER, *Auditors*.

THIRTEENTH AWARD OF THE SOUTH AFRICA MEDAL AND GRANT.

(Fund raised by Members of the British Association in commemoration of their visit to South Africa in 1905.)

After the conclusion of the Presidential Address in the large hall of the Grand Hotel, Bulawayo, on Wednesday, July 14, 1920, the President, Dr. I. B. Pole Evans, presented the South Africa Medal, together with a grant of £50, to Prof. Ernest Warren, D.Sc., Director of the Natal Museum and Head of the Department of Zoology in the Natal University College, Pietermaritzburg. In making the presentation, the President said:—

Dr. Warren was educated at University College, London, where he studied from 1891 to 1894. He graduated first in First Class Honours, qualifying for the Scholarship at the London University B.Sc. examination in 1894. He was appointed Demonstrator in Zoology at the College under the late Professor W. F. R. Weldon. In 1898 he obtained the degree of Doctor of Science at London University for a thesis on the variability of the human skeleton. In 1899 he became Assistant Lecturer and Museum Curator at University College, and in the same year was elected Fellow of the College. In 1903 he was appointed Director of the Natal Government Museum, and in 1908 he was elected a Fellow of the Royal Society of South Africa. He was appointed Professor of Zoology in the Natal University College in 1910.

Dr. Warren has especially worked on biometrics, Cœlenterata and breeding. Some of his chief researches may be briefly mentioned:—

Dr. Warren undertook an extensive statistical investigation on the variability and inter-relationships of the skeleton of an ancient homogeneous human race from Naqada, Egypt, the remains of which were excavated by Professor Flinders Petrie. The very numerous measurements obtained were treated by the modern statistical methods introduced by Professor Karl Pearson. It was demonstrated that the dispersion of the variations about the mean could not be represented by the normal curve of errors, but the theoretical curves which fitted the observations were distinctly skew and had a limited range. The variation in certain dimensions of the body of a population of a species of crab was similarly treated. In order to determine the nature of the variability and strength of inheritance in parthenogenetic generations, breeding experiments were undertaken with *Daphnia* and *Aphis*. On theoretical grounds, Weismann believed that the members of a parthenogenetic family exhibited little variability. It was conclusively shown, however, that very considerable variation occurred and the strength of inheritance between the parthenogenetic mother and offspring was practically the same as in sexual reproduction.

During the last few years, Dr. Warren undertook certain breeding experiments with nasturtiums and foxgloves. The experiments indicate that Mendelian factors must not be regarded as fixed immutable units, but that they are variable in nature and can be transmitted as such to the next generation.

An investigation on the nature of the horny teeth of lampreys and hagfishes showed that these structures are not to be regarded as

degenerate calcified teeth, but rather as primitive, purely ectodermal structures. They may be considered as the first stage in the evolution of the ordinary calcified teeth of vertebrates. Dr. Warren also showed that the maxillary gland of the free-swimming Nauplius larva of a freshwater Crustacean, *Leptodora hyalina*, was purely ectodermal in origin and thus may be homologised embryologically with the nephridia of Chætopoda.

Since his appointment to the Natal Museum, in 1903, Dr. Warren has founded and edited a well-illustrated scientific journal, the "Annals of the Natal Museum," in which, in addition to contributions by himself, important papers have appeared on South African biological research.

Considerable attention has been given by Dr. Warren to the Hydroid fauna of the South African coast. Many new species have been described, and true parasitism among the Hydroids was demonstrated for the first time.

Of a more popular character, Dr. Warren has written articles on "Mammals and Birds of Natal," "South African Birds of Economic Value," and various museum reports and catalogues.

The following is a list of Dr. Warren's published papers:—

1. "Variation in *Portunus depurator.*" *Proc. Royal Soc.*, London (1896).
2. "An investigation on the variability of the human skeleton." *Phil. Trans. Royal Soc.*, London (1898).
3. "An abnormality in *Rana temporaria.*" *Anat. Anzeiger* (1898).
4. "An observation on inheritance in parthenogenesis." *Proc. Royal Soc.*, London (1899).
5. "On the reaction of *Daphnia magna* (Straus) to certain changes in its environment." *Quart. Journ. Micro. Science* (1900).
6. "A preliminary account of the development of the free-swimming Nauplius of *Leptodora hyalina* Lillj." *Proc. Royal Soc.*, London (1901).
7. "On the teeth of *Myxine* and *Petromyzon.*" *Quart. Journ. Micro. Science* (1902).
8. "On the anatomy and development of the Fluke, *Distomum cirrigerum* v. Baer." *Quart. Journ. Micro. Science* (1903).
9. "Preliminary attempt to ascertain the relationship between the size of cell and the size of body in *Daphnia magna* Straus." *Biometrika*, London, vol. ii, pt. 3 (1903).
10. "On *Bertramia kirkmani* sp. n. a Myxosporidium occurring in a South African Rotifer." *Annals Natal Museum*, vol. i, pt. 1 (1906).
11. "On *Tubularia solitaria* sp. n. a Hydroid from the Natal Coast." *Annals Natal Museum*, vol. i, pt. 1 (1906).
12. "On *Halocordyle cooperi* sp. n. a Hydroid from the Natal Coast." *Annals Natal Museum*, vol. i, pt. 1 (1906).
13. "Note on *Convoluta roscoffensis* Graff collected on the Natal Coast." *Annals Natal Museum*, vol. i, pt. 1 (1906).
14. "Note on the abnormal hoofs of a Sheep." *Annals Natal Museum*, vol. i, pt. 1 (1906).
15. "On *Pennaria robusta* sp. n. a Hydroid from the Natal Coast; and also an account of a supposed *Schizophyte* occurring in the gonophores." *Annals Natal Museum*, vol. i, pt. 2 (1907).
16. "Note on the variation in the arrangement of the capitate tentacles in the Hydroid *Halocordyle cooperi.*" *Annals Natal Museum*, vol. i, pt. 2 (1907).
17. "Note on the larva of a Fly (*Sarcophaga* sp.) occurring in the Human Intestine." *Annals Natal Museum*, vol. i (1907).
18. "On a collection of Hydroids mostly from the Natal Coast." *Annals Natal Museum*, vol. i, pt. 3 (1908).
19. "On *Lafœa dispolians* sp. n. a Hydroid parasite on *Sertularia bidens* Bale." *Annals Natal Museum*, vol. ii, pt. 1 (1909).
20. "Notes on the life-histories of Natal Termites, based on the observations of the late Mr. G. D. Haviland." *Annals Natal Museum*, vol. ii, pt. 1 (1910).

21. "Some statistical observations on Termites, mainly based on the work of the late Mr. G. D. Haviland." *Biometrika*, London, vol. No. 4 (1909).
22. "On a black, hairless duiker and dog and a bulldog-headed calf." *Annals Natal Museum*, vol. ii, pt. 2 (1910).
23. "Mammals and birds of Natal." Article in Natal Province Descriptive Guide and Official Hand-book, 1911.
24. "On some specimens of fossil woods in the Natal Museum." *Annals Natal Museum*, vol. ii, pt. 3 (1912).
25. "A case of Hybridism among Cockatoos." *Annals Natal Museum*, vol. iii, pt. 1 (1914).
26. "On the development of the Planula in a certain species of Plumularian Hydroid." *Annals Natal Museum*, vol. iii, pt. 1 (1914).
27. "Note on the occurrence in South Africa of a Termitophilous Beetle of the genus *Corotoca*." *Annals Natal Museum*, vol. iii, pt. 1 (1914).
28. "The parthenogenetic tendency in the Moth *Melanocera menippe* (Westwood)." *Annals Natal Museum*, vol. iii, pt. 2 (1915).
29. "A further note on Hybrid Cockatoos." *Annals Natal Museum*, vol. iii, pt. 2 (1915).
30. "On *Hydrichthys boycei*, a Hydroid parasite on fishes." *Annals Durban Museum*, vol. i, pt. 3 (1916).
31. "A preliminary report on some breeding experiments with Foxgloves." *Biometrika*, London, vol. xi, No. 4 (1917).
32. "On the anatomy of a new South African Hydroid, *Bimeria rigida* sp. n." *Annals Natal Museum*, vol. iv, pt. 1 (1918).
33. "Observations on cellular degeneration and the formation of pigment in certain Hydroids." *Annals of Natal Museum*, vol. iv, pt. 1 (1918).
34. "The Pure Line Hypothesis and the inheritance of small variations." *S.A. Journ. Science*, vol. xv, pp. 535-567 (1918).

Previous Recipients.

1908. *Grahamstown.*—Arnold Theiler, C.M.G., V.M.D., Bacteriologist to the Transvaal Government, Pretoria.

1909. *Bloemfontein.*—Harry Bolus, D.Sc., F.L.S., of Sherwood, Kenilworth, Cape Division.

1910. *Capetown.*—John Carruthers Beattie, D.Sc., F.R.S.E., Professor of Physics, South African College, Capetown.

1911. *Bulawayo.*—Louis Péringuey, D.Sc., F.E.S., F.Z.S., Director of the South African Museum, Capetown.

1912. *Port Elizabeth.*—Alexander William Roberts, D.Sc., F.R.A.S., F.R.S.E., of Lovedale Observatory, C.P.

1913. *Lourenço Marques.*—Arthur William Rogers, M.A., Sc.D., F.G.S., Assistant Director of the Union Geological Survey, Capetown.

1914. *Kimberley.*—Rudolph Marloth, M.A., Ph.D., Capetown.

1915. *Pretoria.*—Charles Pugsley Lounsbury, B.Sc., F.E.S., Chief of the Division of Entomology, Union Department of Agriculture, Pretoria.

1916. *Maritzburg.*—Thomas Robertson Sim, F.L.S., F.R.H.S., formerly Conservator of Forests for Natal.

1917. *Stellenbosch.*—John Dow Fisher Gilchrist, M.A., D.Sc., Ph.D., F.L.S., C.M.Z.S., Professor of Zoology, South African College, Capetown.

1918. *Johannesburg.*—Robert Thorburn Ayton Innes, F.R.S.E., F.R.A.S., Union Astronomer, Johannesburg.

1919. *Kingwilliamstown.*—James Moir, M.A., D.Sc., F.I.C., Government Mining Chemist, Johannesburg.

ASSOCIATION LIBRARY.

The following publications are filed at the Association's Room in the Public Library, Johannesburg.

General Science.

Royal Society of Edinburgh : Proceedings.
Royal Society of South Africa : Transactions.
Royal Society of South Australia : Memoirs.
Royal Society of South Australia : Transactions.
Royal Society of Victoria : Proceedings.
Royal Society of Canada : Proceedings and Transactions.
Royal Society of Tasmania : Papers and Proceedings.
Royal Society of Queensland : Proceedings.
Royal Dublin Society : Scientific Proceedings.
Royal Institution of Great Britain : Proceedings.
Royal Philosophical Society of Glasgow : Proceedings.
Royal Society of Arts : Journal.
Michigan Academy of Science : Reports.
Chicago Academy of Sciences :
  Bulletins
  Special Publications.
Reale Academia dei Lincei, Rome : Atti.
Kungl. Svenska Vetenskapsakademien :
  Handlingar.
  Arsbok.
Koninklijke Akademie van Wetenschappen, Amsterdam :
  Proceedings of the Section of Sciences.
  Verhandelingen.
Real Academia de Ciencias de Madrid : Revista.
British Association for the Advancement of Science : Reports.
Australasian Association for the Advancement of Science : Reports.
American Association for the Advancement of Science : Proceedings.
Indian Association for the Cultivation of Science :
  Proceedings.
  Reports.
  Bulletins.
Società Italiàna por il progresso delle Scienze : Atti.
Association Française pour l'avancement des Sciences : Conférences.
Cambridge Philosophical Society :
  Transactions.
  Proceedings.
Manchester Literary and Philosophical Society : Memoirs and Proceedings.
American Philosophical Society : Proceedings.
University of California :
  Bulletins.
  Memoirs.
University of Virginia : Philosophical Society Bulletins.
Tôhoku Imperial University : Science Reports.
New York Academy of Sciences : Annals.
American Academy of Arts and Sciences : Proceedings.
Connecticut Academy of Arts and Sciences : Transactions.
Meddelanden fran K. Vetenskapsakademien Nobelinstitut.
California Academy of Sciences : Proceedings.
Academy of Science of St. Louis : Transactions.
Academy of Natural Sciences of Philadelphia : Proceedings.
American Journal of Science.
Ohio Journal of Science.
Nova Scotian Institute of Science : Proceedings and Transactions.
Revue Générale des Sciences.
Archives Néerlandaises des sciences exactes et naturelles.
Annaes scientificos da Academia polytechnica do Porto.

Rhodesia Scientific Association :
Proceedings.
Annual Reports.
Société de physique et d'histoire naturelle de Genève :
Memoires
Comptes rendus.
Det Kongelige Norske Videnskapers Selskaps Skrifter.
Kongelige Danske Videnskabernes Selskab : Oversigt.
Vierteljahrsschrift der naturforschenden Gesellschaft, Zurich.
Imperial Institute : Bulletins.
New Zealand Institute : Transactions and Proceedings.
Annual Report of the Smithsonian Institute.
Annual Report of the Smithsonian Institution (United States National Museum).
South African Museum :
Annals.
Annual Reports.
Transvaal Museum : Annuals.
Natal Museum : Annals.
Queensland Museum :
Annals.
Memoirs.
Field Museum of Natural History Publications.
University of Pennsylvania Museum Journal.
Public Museum of Milwaukee : Bulletins.
Albany Museum :
Annual Reports.
Records.
Knowledge.
Science.
Franklin Institute : Journal.
University of Minnesota : Current Problems.

Chemistry, Metallurgy, and Geology.

Chemical, Metallurgical, and Mining Society of South Africa : Journal.
Kungl. Svenska Vetenskapsakademien : Arkiv för Kemi, Mineralogi, och Geologi.
Geological Society of South Africa : Transactions.
Geological Society of Tokyo : Journal.
Geological Survey of New South Wales : Reports.
Memoirs.
Mineral Resources.
Geological Institution of the University of Upsala : Bulletins.
Geological Society, London : Abstracts of Proceedings
Bulletins of the Wyoming State Geologist.
United States Geological Survey :
Annual Reports.
Mineral Resources.
Bulletins.
Monographs.
Professional Papers.
Florida State Geological Survey : Annual Reports.
Servico geologico e mineralogico do Brasil : Monographias.
Union of South Africa Mines Department : Annual Reports.
Canada Department of Mines :
Museum Bulletins.
Memoirs of the Geological Survey.
Reports.
New South Wales Department of Mines : Annual Reports.
The Mineralogical Magazine.
Egyptian Ministry of Finance : Geological Reports.
Geological Survey of Western Australia :
Annual Progress Reports.
Bulletins.
Journal of Industrial and Engineering Chemistry.

Journal of Chemical Technology.
The Chemical News.
University of Minnesota: Studies in Chemistry.
South African Association of Analytical Chemists: Proceedings.

Meteorology,

Royal Meteorological Society: Quarterly Journal.
Mount Weather Observatory: Bulletins.
Observatorio Campos Rodrigues:
  Relatorio.
  Resumo mensal.
Egyptian Ministry of Finance: Meteorological Reports.

Agriculture

Regia Scuola superiore agricoltura di Portici: Annali.
International Institute of Agriculture, Rome:
  International Crop Report and Agricultural Statistics.
  International Review of the Science and Practice of Agriculture.
  Documentary Leaflets.
  Statistical Notes on the Cereals.
Massachusetts Agricultural Experiment Station:
  Annual Reports.
  Bulletins.
Maine Agricultural Experiment Station: Annual Reports.
Agricultural Gazette of New South Wales.
Department of Agriculture, New South Wales: Science Bulletins.
United States Department of Agriculture:
  Experiment Station Record.
  Year Book.
New York State College of Agriculture and Experiment Station:
  Annual Reports.
Journal of Agricultural Research.
Rhodesia Agricultural Journal.
Revista de Agricultura, Comercio y Trabajo, Cuba.
Bulletin Agricole de l'Algerie-Tunisie-Maroc.
Station agronomique de la Guadeloupe: Bulletin.
Union of South Africa Agricultural Journal.

Biology and Physiology.

Bulletin de la Société Imperiale des naturalistes de Moscou.
Kungl. Svenska Vetenskapsakademien:
  Arkiv för Botanik.
  Arkiv för Zoologi.
Journal of the Linnean Society, Botany.
Bulletin of the Wisconsin Natural History Society.
The Medical Journal of South Africa.
University of California: Publications in Botany.
Linnean Society of New South Wales: Proceedings.
Missouri Botanical Garden:
  Annual Reports.
  Annals.
Bolus Herbarium: Annals.
Smithsonian Institution (United States National Museum): Contributions from the United States National Herbarium.
Royal Botanic Gardens, Kew: Bulletins.
Union of South Africa: Reports of the Director of Veterinary Research.
The Australian Zoologist.
University of Michigan, Museum of Zoology:
  Miscellaneous Publications.
  Occasional Papers.
Lloyd Library:
  Bibliographical contributions.
  Mycological Notes.
South African Biological Society: Bulletins.

Entomology.

Bulletin of Entomological Research.
Review of Applied Entomology.

Bacteriology.

Abstracts of Bacteriology.

Astronomy, Mathematics and Physics.

Royal Astronomical Society
- Memoirs.
- Monthly Notices.

Journal of the Royal Astronomical Society of Canada.
Harvard College Astronomical Observatory:
- Circulars.
- Annals.
- Annual Reports.

Leyden Sterrenwacht: Annalen.
Union Observatory Circulars.
Cape Observatory:
- Annals.
- Reports.
- Cape Astrographic Zones.

Observatoire Royal de Belgique; annuaire astronomique.
Khedivial Observatory, Helwan, Egypt: Bulletins.
Kodaikanal Observatory: Bulletins.
Kodaikanal and Madras Observatories: Annual Reports.
British Astronomical Association.
- Journal.
- Memoirs.

Lick Observatory: Bulletins.
Nizamiah Observatory: Reports.
Astronomical Society of India:
- Journal.
- Monthly Notices.

United States Naval Observatory Publications.
American Ephemeris and Nautical Almanac.
Western Australian Astronomical Society: Proceedings.
Kungl. Svenska Vetenskapsakademien: Arkiv för Matematik, Astronomi och Fysik.
London Mathematical Society: Proceedings.
Tôhoku Mathematical Journal.
National Physical Laboratory, Middlesex:
- Collected Researches.
- Reports.

University of Minnesota: Studies in the Physical Sciences and Mathematics.
Universidad Nacional de la Plata: Contribucion al estudio de las Ciencias fisicas y matematicas.
Physical Society of London: Proceedings.

Educational, Political Economy and Sociology.

United Empire.
South Africa.
Ohio State University Bulletin.
International Institute of Agriculture, Rome: International Review of Agricultural Economics.
Royal Dublin Society: Economic Proceedings.
Athenæum subject index to Periodicals.
Municipal Journal of South Africa.
University of Minnesota:
- Studies in Economics.
- Studies in Public Health.
- Studies in the Social Sciences.

Geography, Oceanography and Hydrography.

Società Italiana per il progresso delle Scienze: Comitato talassografico:
- Bolletinos.
- Memorias.

The Geographical Journal.
The Geographical Review.
United States Geological Survey: Water Supply Papers.
Egyptian Ministry of Finance: Survey Department Papers.
Instituto di geografia fisica e vulcanologica della R. Universita di Catania: Pubblicazioni.
United States Department of Commerce, Coast and Geodetic Survey:
Special Publications.
Annual Reports.

Engineering.

Proceedings of the American Institute of Electrical Engineers.
Journal of the South African Institution of Engineers.
Transactions of the South African Institute of Electrical Engineers
South African Society of Civil Engineers: Proceedings.
South African Engineering.
University of Minnesota: Studies in Engineering.

Technology.

Patents for Inventions: Abridgments of Specifications.
The Illustrated Official Patents Journal.
South African Journal of Industries.

Anthropology and Ethnology.

Journal of the African Society.
University of Minnesota: Studies in Language and Literature.

Archæology.

Bulletins of the Archæological Survey of Nubia.

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Assistant General Secretary:

H. A. G. Jeffreys, P.O. Box 6894, Johannesburg. (Telegraphic Address: "Science.")

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Transvaal—Outside.

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THE VELD: ITS RESOURCES AND DANGERS.*

BY

I. B. Pole Evans, M.A., D.Sc., F.L.S.,
President,

Chief, Division of Botany & Plant Pathology and Director of the Botanical Survey, Union of South Africa.

With Plates I—XXVIII, and 1 Map.

Presidential Address delivered July 14, 1920.

As is customary on occasions like this I have several short and time-honoured digressions to make before coming to the subject of my address First of all it is my painful duty to refer to the loss which the country has sustained, since we last met, in the death of two distinguished South Africans. One of these was a past President of this Association, Sir Hamilton Goold-Adams—formerly Governor of the Orange Free State—who took the chair at the meetings of this Association at Bloemfontein in 1909. Sir Hamilton was keenly interested in science and all its applications, and anyone who reads his presidential address, delivered just over ten years ago, cannot help being forcibly impressed by the wisdom of his words and the urgent need which then existed for their application.

Then in the death of General Botha, not only South Africa, but the world at large has suffered a very grievous loss. Although the first Union Premier was not a member of this Association he took a most active part in the scientific development of the country, and as one who speaks from personal experience, having been privileged to serve under him, I can say without fear of contradiction that he has been largely responsible for the rapid agricultural development of the Union through the unstinted and encouraging support which he always rendered his technical advisers. He gave more than careful and sympathetic consideration to any reasonable proposals for the advancement of the country's prosperity. Although he is regarded by the majority only as a great politician, in reality he was imbued with the true scientific spirit, and like Science herself took no cognisance of race, nationality or party where questions of truth, knowledge and the world's welfare were concerned. His was a marvellous personality, he was everyone's friend. Ill can South Africa and Science in general afford to lose so noble a statesman.

Secondly, I wish to convey to the members of this Association my very great appreciation of the honour which they have done

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* Illustrated by lantern slides from the author's photographs.

me in electing me to the Presidential Chair, and I trust to their kindly forbearance in overlooking any shortcomings in my attempt to fill worthily so responsible a position.

Finally, it is with unbounded pleasure that I extend to you, Mr. Chairman, and to the citizens of Bulawayo our deep appreciation of the compliment you have paid us in inviting us to return to this city when so short a period has elapsed since our last visit. South Africa is essentially a country of surprises, and I feel is destined to become one of rapid progress. I am sure, therefore, that after we have availed ourselves of your cordial hospitality, those of us who were here some nine years ago will leave your "land of ancient ruins" more impressed than ever with its surging progress, its vast potentialities and the enormous possibilities which exist for the application of science in all its phases.

As regards this Association the period since we last met here has been one of steady progress, and its objects are being slowly but surely achieved. In this connection I can not do better than refer you to the able review of the Association's history and activities given by Prof. John Orr in his Presidential Address at Stellenbosch some three years ago. I cannot, however, refrain from drawing particular attention to the remarkable growth in the number of papers which in the past few years have dealt with some aspect of biology. This may be taken as a sign of the times, and might be quoted as an encouraging symptom, showing that South Africa is fully alive to the importance of the study of the biological sciences.

In looking through the list of our past Presidents, I find that Botany has only once before been honoured with the Presidential Chair. This was some six years ago, at Kimberley, when our distinguished botanist, Dr. Marloth, presided over the meeting and was at the same time awarded the Society's medal for his services to Botanical Science. Dr. Marloth took as the subject of his address—"Some Problems of Botanical Research in South Africa"—and his opening sentences were as follows:—

> "I shall, for the sake of convenience, deal first with such questions as are specially connected with the material welfare of the country. It is too often overlooked that there is nothing of greater importance to us in a country than its vegetation, that the vegetation of a country is the basis of all life, and without it neither animal nor man could live there, unless maintained by artificial means and imports."

Well may we pause and ask ourselves how many of us realise to the full the significance of these words. Those of us who toil in the Public Service know to our cost the views held by the average pedantic official, who regards the study of botany as an expensive hobby, to be looked upon with condescending tolerance rather than as a vital necessity of an agricultural country and as such demanding every support and encouragement. If some of our officials are still dull and antiquated in this respect, we can

congratulate ourselves that our landowners, legislators, and labourers are alive to its vast importance and in recent years have taken steps to provide facilities for the study of the vegetation of the country. South Africa has during the last few years attained so worthy a place in the ranks of scientific progress that a well-known scientific publication recently referred to "the enlightenment of outlook in matters connected with the bearing of scientific knowledge on practical affairs, which experience has taught us to expect on the part of the Government of the Union of South Africa."

Marloth in his address alluded to the many problems awaiting investigation, pointed out the difficulties under which the early botanists laboured and drew attention to the backwardness of South Africa as compared with other countries with regard to facilities provided by the State for botanical research. He was, however, sufficiently alert to detect a silver lining to the cloud, and mentioned, among other things, the recent establishment of the National Gardens at Kirstenbosch, and the provision of grants for research by the Union Government.

Although it is only six years since his address was delivered, considerable progress has been made in the interval, and I propose briefly to take up the subject where Marloth left it, and give a short résumé of what has been done since those days. First and foremost, the Government of the Union of South Africa has established a Botanical Survey for the purposes of which the Union has been divided into definite areas. The survey of each area is being carried out under the supervision of an experienced botanist, and funds are provided by the State to give facilities for research and survey to those working in co-operation with the botanists in charge. This is a great step in advance of former times and is one of which those botanists who worked together in loyal co-operation have every reason to be proud. It is also pleasing to report that the progress already achieved is more than gratifying and assuring.

While the State has been carrying out its obligations to the country, I think I shall have no difficulty in convincing you that the workers—few though they are—have not been backward in doing their part.

During the period under review Marloth has continued his magnificent work on the flora of South Africa, Bews has made an exhaustive study of the vegetation of Natal, Pearson has botanically explored South-West Africa, and Schönland has published a Memoir on the flora of Uitenhage and Port Elizabeth. Mrs. Bolus is engaged on a study of the flora of the Cape Peninsula, Phillips has made a botanical survey of Basutoland, French Hoek and the Great Winterhoek, and Hepburn has published a paper on the flora of Herschel.

In addition to the description of botanical regions detailed above a number of monographs on genera and families of phanerogamic plants have been published, or are in course of

preparation. Schönland has worked up one of the most important families of succulents, the *Crassulaceae*, and has revised the genus *Rhus* and is making a study of the *Cyperaceae*. Mrs. Bolus is studying the *Mesembryanthemums*, while Pillans, another worker in the South Western area, is busy with the *Restiaceae*. Phillips has added to our knowledge of the S.A. *Proteaceae* and has published monographs on the genera *Calpurnia*, *Cyphia* and *Borbonia*; in collaboration with Kotze he has reviewed the genus *Faurea*, and *Pteronia* in collaboration with Hutchinson. Miss Verdoorn, one of the assistants in the National Herbarium, has worked on the Transvaal *Primulines* and the genus *Fagara*. From the economic standpoint one of the most important pieces of work is the veld burning experiments which Phillips has in hand at Groenkloof, near Pretoria, and on which he has published a preliminary report. Also of great importance from an economic standpoint is the work which is being carried out by Miss Stent on indigenous grasses and their distribution throughout the Union and on the plants poisonous to stock.

In addition to the workers mentioned above who are making a study of the distribution and classification of plants, there are a large number of enthusiastic and careful collectors who have rendered valuable assistance and who have donated their collections to public institutions. One of the foremost of these is Mr. E. E. Galpin, who has presented his unique herbarium of Transvaal and Cape plants to the National Herbarium and is now making further collections and studying the vegetation of the Waterberg District of the Transvaal. Amongst numerous other collectors might be mentioned Madame Dieterlen whose Basutoland plants form an invaluable addition to the National Herbarium, and Madame Borle and the Rev. Junod who are making exhaustive collections in Portuguese East Africa. Dr. Rattray, Miss Guthrie, and J. D. Keet have made their contributions from the Cape Province, Pierce is collecting in Swaziland, Mogg is specialising in areas where cattle diseases are prevalent, E. G. Bryant, Mrs. Jones, and Miss McCallum are keenly interested in Transvaal plants, Potgieter and Putterill have done useful work in the Free State, and Archdeacon Rogers is well known as an enthusiastic and intelligent collector. Mr. Fred Eyles has added very considerably to our knowledge of the flora of Rhodesia and has published a valuable list of the plants known to occur in that country.

Although the bulk of the work accomplished has been in connection with the phanerogamic flora, the study of the cryptograms has not been altogether neglected. Sim is making a study of the mosses and hepatics and has published the first section of his monograph on the subject. A study of the fungi of the country is greatly facilitated by the unique and invaluable collection in the cryptogamic section of the National Herbarium, which is assuming vast proportions under the care of Miss Bottomley. I have continued my study of the rust fungi, having published a paper on the rusts affecting the Compositae, and in collaboration with Miss Bottomley have written on the genera

Diplocystis and *Broomeia* and have compiled a list of the fungi collected by Miss Pegler at Kentani. Miss Pegler has been one of the keenest and most enthusiastic of the collectors who have contributed valuable specimens to the cryptogamic herbarium; others who have made important contributions are Cruden, also in the Eastern Province, Eyles and Swynnerton in Rhodesia, Junod in Portuguese East Africa and Potts in the Free State.

Van der Bijl has made a study of the Polyporaceae. Several papers have been published dealing particularly with the economic aspect of this group and their influence on the forest vegetation, and a contribution to our knowledge of the distribution and classification of the group will be laid before the present meeting.

Dr. Ethel Doidge is devoting her attention to certain groups of the Ascomycetes and has published several papers dealing with the South African species of *Erysiphaceae*, *Perisporiaceae* and *Microthyriaceae*.

I should not omit to mention, with deep regret, that during this period our ranks have been depleted by the death of that strenuous and able botanist, Pearson, of that careful and enthusiastic collector, H. G. Flanagan, and of W. Tyson, who has made large and valuable collections of marine Algae. We have also lost during the past year Maurice Evans, whose name will always be associated with that of Medley Wood in Natal. On the other hand we wish to welcome to our midst such well-known colleagues as Professors Moss, Thoday and Compton, and Mrs. Thoday (M. G. Sykes).

I must now proceed to the subject of my address. To one whose duties are of a wide and varying character the choice of a subject must always be somewhat bewildering. For from the nature of things where the subjects are numerous the knowledge of each can but be superficial. My duties include the supervision of the Botanical Survey, advice on all matters of a botanical nature, and the investigation, prevention, control, and eradication of plant diseases within the Union. It is obvious that much of this work carries me into the veld, and I have therefore had exceptional opportunities of making observations on the veld throughout South Africa during the past 15 years. Many of these journeys have been of a very hurried nature, but by means of the series of photographs which I have accumulated, and some of which I hope to put on the screen, I have obtained a general knowledge of the veld conditions in some of the less known parts of the country. I propose therefore to give briefly some account of:—

The Veld: Its Resources and Dangers.

It is hardly necessary to attempt to explain to a South African audience the meaning of the word "veld," but in order to avoid misapprehension I may say that by the word "veld" I mean merely the natural vegetation of the country. The word therefore implies not only the plant growth of any locality, but also has reference to the habitat in which the plants grow. The

study of the veld is not new, it has received considerable attention at the hands of the botanists and travellers from the earliest times. Some 17 years ago Marloth gave this Association an admirable account of these early explorers, including such men as Burchell, Drège and Rehmann, and in that magnificently illustrated work "Das Kapland" published in 1908, he reviewed in detail the valuable additions to our knowledge of the veld which have been made by Bolus, Medley Wood, and Sim; and at the same time places on record a vast accumulation of facts embodying his own detailed observations.

The main types of vegetation throughout the world are largely determined by rainfall and climate, and as both of these are influenced by the topography of the country any attempt to classify the different types of veld must take all these facts into consideration. I therefore consulted my colleague Dr. Rogers, Director of the Geological Survey, who at once kindly furnished me with a map and an account of the chief physical features of South Africa. He recognises three main physical features—

I. The Interior Plateau.
II. The Great Escarpment.
III. The country between the Great Escarpment and the sea.

I.—The Interior Plateau.

In the Interior Plateau Rogers recognised ten main regions:—

1. The High Veld.
2. The Middle Veld.
3. The Upper Karroo.
4. The Basuto Highland.
5. The Limpopo Highland.
6. The Bushveld.
7. The Kalahari and Bushmanland.
8. The Kaap Plateau.
9. The Namaqua Highland.
10. The Low Country (including much country below the escarpment).

The country below the escarpment he divides into four regions:—

1. The Great Karroo.
2. The South-Eastern Region.
3. The Folded Belt.
4. Coastal Belt.

These divisions were, of course, made from a consideration of their geological formation, altitude and past geological history. If, however, they are examined from the point of view of the vegetation it will be found that they form a very satisfactory basis for the division of the country into plant regions, and many of the divisions correspond very closely with vegetation maps of

South Africa published by Bolus, Marloth and myself. I propose now to give a brief characterisation of each botanical region to show that the main types of vegetation occurring in South Africa are intimately associated with the physical features of the country, and shall then deal with each region in somewhat greater detail. (See map on page 9.)

1. *The Coast Veld.*—Identical in extent with portions of Dr. Rogers' coast belt, a region of drowned valleys and sandy dunes which are covered with dense impenetrable bush, tall grasses and palms. Isolated evergreen forests are frequent.

2. *The Low Veld* or low country.—A region of low relief, of wide open river valleys with perennial streams and deep alluvial soils, which are covered with gigantic thorn and other deciduous trees beneath which a rank growth of grass persists.

3. *The Eastern Grass Veld.*—Including the South-eastern region, the Great Escarpment and the Basuto Highlands, a region of terraced landscapes and deep valleys with perennial streams. The soil is well covered with a grassy turf in which scattered thorn trees occur in the more open country and evergreen forests in the sheltered kloofs.

4. *The Bushveld.*—A region of flat low-lying country with perennial streams and deep soils. It is covered with grass, but well overgrown with deciduous bush and trees.

5. *The Middle or Banken Veld.*—A region of gently sloping hills, from which more or less straight belts or escarpments of harder rock project. The hill slopes are covered with grass, while the rocky belts are clothed with stunted deciduous trees and sclerophyllous bush.

6. *The High Veld.*—A region of vast rolling tablelands, of horizontal strata and deep soils which are covered with a dense grassy turf and devoid of indigenous trees and bush; well supplied with perennial streams.

7. *The Pietersburg Highveld.*—An undulating plateau of deep sandy soil, covered with grass and scattered bush.

8. *The Waterberg Sandveld.*—A mountainous tract of country, devoid of perennial streams, and with shallow, sandy soil which is covered with grass. On the hill slopes there are scattered deciduous trees and sclerophyllous bush.

9. *The Griqualand West Thorn Veld.*—A region of long, open river valleys—the chief of which are the valleys of the Dry Harts, the Harts and Vaal Rivers—with deep alluvial soil and gravels which support a park-like growth of thorn trees and tufted grasses.

10. *The Kaap Plateau Bush Veld.*—A region composed of an extensive dolomite and limestone plateau, devoid of rivers but well supplied with pans which are usually dry. The soil is shallow, and covered with bush, xerophytic shrub, shrublets and grass.

11. *The Vaal Kameeldoorn Veld of the Asbestos Mountains.*—A region of undulating country, stony and rocky hills, sandy

plains and dry river valleys. The hills are covered with scrub in which the Ijstervark bos (*Lebeckia macracantha*) and Vaal bos (*Torchonanthus camphoratus*) predominate. On the sandy plains there are grass and Vaal Kameeldoorn, while the low-lying valleys support a growth of "brak" and xerophytic shrublets.

12. *The Kalahari Sand Veld.*—A region of undulating sandy plains and dunes, dry river beds and internal drainage. In some places the plains support only a growth of brak plants, on others grass and thorn trees, while the dunes are covered with coarse grass and isolated Witgat trees.

13. *The Damaraland Thorn Veld.*—A region of mountainous country with a dry and arid appearance. The vegetation is composed mainly of thorn bush and succulents, with a scanty clothing of grass.

14. *The Kameeldoorn Veld of South Damaraland.*—A region of vast deep sandy plains which support a park-like growth of gigantic thorn trees, below which low thorn scrub and scanty grass subsist.

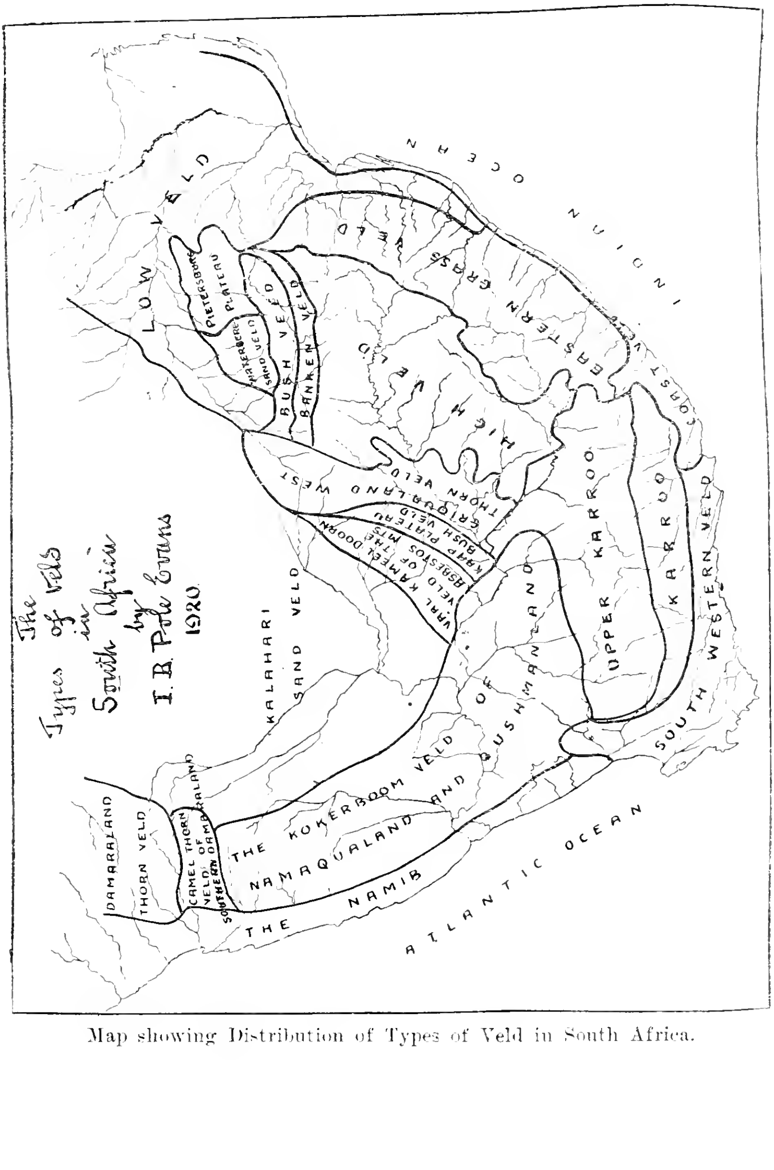
15. *The South Western Veld.*—A region of mountainous character with a great variety of soil and climate, in which the vegetation is composed mainly of sclerophyllous bush and shrublets, with an abundance of bulbous and sedge-like plants (*Restiads*).

16. *The Karroo.*—A region of low-lying relief in the north, but somewhat broken in the south by the Cape ranges, characterised by dry river beds, shallow soils and rock-exposed surfaces. The vegetation is composed mainly of succulents, bulbous and tuberous plants.

17. *The Upper Karroo.*—A region of wide plains broken by table-topped hills and spitzkops, with dry river valleys, shallow soils and rocky surfaces. The vegetation is composed of low-growing and scattered xerophytic shrublets.

18. *The Kokerboom Veld of Namaqualand and Bushmanland.*—A region of vast arid plateaux and plains, dry river beds and bare stony or sandy surfaces. The vegetation is scanty and consists of isolated tufts of grass, stunted bushes and shrublets on the plateaux and plains, and the Kokerboom (*Aloe dichotoma*) and Giftboom (*Euphorbia virosa*) on the rocky hills.

19. *The Namib or Western Littoral Belt.*—A region of drifting and shifting sand dunes, of gravel plains and barren rock surfaces. The vegetation is extremely scanty and consists of a few grasses and succulents on the dunes and gravel plains, of xerophytic shrubs and succulents on the rock surfaces, of the Narras (*Acanthosicyos horrida*) and Tamarisk (*Tamarix articulata*) on the submerged river mouths and of the Aggenys Euphorbia (*E. gregaria*) in the open valleys.



Map showing Distribution of Types of Veld in South Africa.

I.—The Coast Veld (*Plate I*).

Fringing the shore and covering the littoral dunes from Algoa Bay to our northern boundary is a type of veld more luxuriant and tropical in character than that seen in any other part of South Africa.

This is due to the fact that the rainfall along this coast belt is heavier than elsewhere, the greater portion of it falling during the summer months. The temperature along the coast is comparatively uniform and sub-tropical; frosts seldom, if ever, occur.

This type of veld extends from the sea-level to an altitude of about 1,000 feet, and is composed mainly of dense bush and evergreen forest patches. Growing just at and above high water mark in the loose sand is the *Scaevola lobelia* and *Ipomaea biloba* association, and between this and the dense bush the sand is often covered with *Gazania uniflora*, *Cyperus natalensis*, *Cynanchum obtusifolium*, *Passerina ericoides*, *Samolus porosus*, *Osteospermum moniliferum*, *Dimorphotheca fruticosa*, *Strelitzia augusta*, *Phœnix reclinata*, *Hyphaene crinita*, *Brachylæna discolor* and *Carissa grandiflora*.

The Coastal bush ranges from 10 to 30 ft. in height, and forms a dense almost impenetrable growth, in which such trees as the Red Milkwood (*Mimusops caffra*), the Thorn Pear (*Scolopia Zeyheri*), the White Pear (*Apodytes dimidiata*), the Wild Coffee (*Kraussia lanceolata*), the Kaffir Boom (*Erythrina caffra*), the Bitter Blaar (*Brachylœna elliptica*), the Kaffir Plum (*Harpephyllum caffrum*), the Saffraan (*Elaeodendron croceum*), *Schmidelia erosa*, *Euclea natalensis* are woven together by climbing plants such as *Vitis capensis*, *Entada natalensis*, *Dregea floribunda*, *Helinus ovatus*, *Scutia Commersonii*, *Flagellaria guiniensis* and *Grewia lasiocarpa*. Closely associated with this bush, but usually growing on the inland side and in more open country, is the flat-crown *Albizzia fastigiata* which is typical of this bush veld.

Wherever lagoons occur along the coast the mangroves (*Avicennia officinalis*, *Rhizophora mucronata*, and *Bruguiera gymnorrhiza*) are characteristic of the mud swamps, while *Hibiscus tiliaceus* fringes the edge of the river estuaries.

There are several important forests in this East Coast Veld. Chief amongst these are the forests in the neighbourhood of East London, which are peculiar in that they consist in places of almost pure associations of Cape Box (*Buxus MacOwani*), the Saffraan (*Elaeodendron croceum*), the Sneezewood (*Ptaeroxylon utile*) and Umbiza (*Umbiza Listeriana*).

The Manubi Forest, which is situated a little further north along the coast, contains most of the trees common to the forests of the Transkei and in addition yields fine specimens of Umzimbeet (*Millettia caffra*), Cape Mahogany (*Trichilia emetica*) and Essenhout (*Ekebergia capensis*).

Still further north the Egossa forest occupies a coastal belt of about 20 miles in Pondoland, north of Port St. John, and is about two miles in width. Conspicuous trees in the Egossa are

the Beukenhout (*Faurea McNaughtonii*), the Cape Mahogany (*Trichilia emetica*), the Umzimbeet (*Milletia caffra*), the Umkunye (*Milletia Sutherlandi*), the Bastard White Ironwood (*Cyclostemon argutus*) and the Cape Ebony (*Heywoodia lucens*).

In spite of the high rainfall in this region, it is not devoid of succulents, and several interesting and typical species are found there. The chief amongst these in the southern portion are two species of Euphorbia (*E. grandidens*, *E. tetragona*) and *Aloe africana*. *Euphorbia ingens* and *Aloe Thraskii* occur in the north.

The chief economic products of the Coast Veld are:—

1. Timber from the Cape Box, Sneezewood, Saffraan, Vlier, Umtiza, White Milkwood, Kaffir Plum, White Ironwood, Cape Mahogany, Umzimbeet, Wild Chestnut, Red Currant, Hard Pear, and Cape Ebony.

2. Tanning materials from the mangroves:—*Avicennia officinalis*, *Rhizophora mucronata*, *Bruguiera gymnorrhiza* and *Ceriops Candolleana*.

3. Fibre weaving materials from the palms *Phœnix reclinata* and *Hyphæne crinita*, and also from *Urera tenax* and the so-called Wild Banana, *Strelitzia augusta*.

4. Rubber from *Landolphia Kirkii* and *Euphorbia Tirucalli*.

5. Oil from *Telfaria pedata* and *Trichilia emetica*.

2.—The Low Veld (*Plates II, III*)

The Low Veld comprises the country situated in the north-eastern corner of the area under review. It includes part of the northern and north-eastern Transvaal, the southern corner of Portuguese East Africa, the eastern portion of Swaziland, and the greater part of Zululand. The Tugela River forms the southern boundary, while the Limpopo must be taken as its northern limit so far as this address is concerned.

On the whole the Low Veld consists mainly of flat low-lying country, which ranges from an altitude of 400 ft. to 2,000 ft. above sea level. It is well supplied with perennial streams and rivers, amongst which the most important are the Tugela, the Umhlatusi, the Umfolosi, the Pongola, the Maputa, the Umbelusi, the Komati, the Olifants, the Letaba and the Limpopo with their tributaries.

Between the two boundaries just mentioned, the Low Veld, except for a narrow coastal strip, stretches from the Indian Ocean on the east to the foothills of the Great Escarpment formed by the Drakensberg Range on the west. In the extreme north, where the Limpopo Valley has worn through the range, the Low Veld extends for some little distance behind the Escarpment, as far as the valley of the Crocodile River.

The larger portion lying between the Great Escarpment and the Indian Ocean is traversed almost throughout its entire length by the Lebombo Range, a low-lying range of mountains which run almost due south and north.

Apart from this range of mountains the general uniformity of the country is seldom broken, except here and there by a few

out-cropping kopjes usually composed of massive boulders of granite. The rainfall in this area varies very considerably and may be from 70 inches in the eastern portion to 15 inches in the extreme western.

The general aspect of the veld is park-like, that is to say, it is covered with trees which vary in height from 30 to 50 ft., but which are sufficiently far apart to allow means of existence for a dense growth of grass, undershrubs and herbs. Along the river valleys the vegetation is much more luxuriant in character.

Inland lakes, pans, and lagoons are also not uncommon in this area.

The greater part of the vegetation in the Low Veld can be described as a Thorn Veld, in which the Knoppiesdoorn (*Acacia pallens*) is one of the most characteristic and dominant trees, especially in the dry open country. Other common trees typical of the Low Veld are:—The Maroola (*Sclerocarya caffra*), the Tambootie (*Excoecaria africana*), the Jakhalsbossie (*Diospyros mespiliformis*), the Hardekool (*Combretum porphyrolepis*), the Waterhout (*Syzygium cordatum*), the Van Wyk's hout (*Bolusanthus speciosus*) the Boerboom (*Schotia brachypetala*), the Huilbos (*Peltophorum africanum*), the Sikkelbos (*Dichrostachys nutans*), the Haaken-steek (*Acacia spirocarpoides*), the Fever tree (*Acacia xanthophloea*), the Mingerhout (*Adina Galpini*), the Ruikpeul (*Acacia arabica* var. *kraussiana*), *Lonchocarpus mossambicensis* and *Androstachys Johnsoni*.

On the deep alluvial flats in Portuguese East Africa the Mahogany tree (*Afzelia quanzensis*), the Rooi Essehout (*Trichilia emetica*), the Sausage-tree (*Kigelia pinnata*) the Hardepeer (*Strychnos Henningsii*) and *Brachystegia appendiculata* occur more frequently.

At higher altitudes just below the foothills of the Drakensberg the Kajatenhout (*Pterocarpus erinaceus*) and Bastard Kameel Doorn (*Acacia lasiopetala*) are common, the former often becoming the most abundant tree in the veld. With these two the Grijsappelboom (*Parinarium mobala*) is frequently associated.

On the Olifants River, *Croton Gubonga* is plentiful along the banks, while *Terminalia pruinoides* and *Balsamodendron Africanum* dominate the bush in the drier valleys.

In the Limpopo Valley in the Northern Transvaal the Baobab (*Adansonia digitata*) and Mopane (*Copaifera mopane*) are characteristic of the Low Veld.

The Low Veld is undoubtedly the most fertile tract of country in South Africa. Its variety of soils and sub-tropical or tropical climate render it eminently suitable for agricultural purposes.

Sugar is the main crop cultivated in the southern portion, while much of the land towards the north is suitable for ranching and the cultivation of fibre and oil crops.

The natural resources in this area include much valuable timber, which is yielded by such trees as the Kajatenhout — *Pterocarpus erinaceus*, the Mahogany *Afzelia quanzensis*

Mull., the Ebony *Diospyros mespiliformis* Hochst., the Rooi Essehout *Trichilia emetica* Vahl., the Mingerhout *Adina Galpinii* Oliv., the White Pear *Apodytes dimidiata* E. Mey., and the bastard ironwood *Cyclostemon argustus* Muell. First-rate timber for poles and mine props can be obtained from the Knoppiesdoon, *Acacia pallens*, or from *Acacia Welwitschii* and *Acacia rostrata*.

Tanning materials are obtainable from at least three different kinds of Mangrove, viz.:—*Rhizophora mucronata* Lam., *Bruguiera gymnorrhiza* Lam., and *Ceriops Candolleana* Arn. Trees of *Acacia Benthami* are extremely plentiful throughout the area and yield an abundance of pods which serve as a valuable article for tanning purposes and also as a cattle food.

Fibres are obtained from the bark of the trees *Ficus utilis* Sim, and *Securidaca longipedunculata* Fres., and from the stems of *Hibiscus cannabinus* and other members of the order *Malvaceae*.

The tall grasses in this region furnish material which is eminently suitable for paper-making.

The fruits of *Trichilia emetica* Vahl., *Ximenia americana* Linn., and *Xanthoxylum capense* Sim., all yield a high percentage of oil.

Landolphia Kirkii, Dyer, which occurs from the Umhlatusi in Natal to the Limpopo, yields excellent rubber, while gums of good quality might well be obtained from the different species of *Acacia*, *Combretum*, and *Commiphora*.

3.—The Eastern Grass Veld (*Plates V, VI*).

Lying between the coast veld and the Great Escarpment, from an altitude of 1,000 ft. upwards, is a fairly extensive tract of terraced country, well covered with grass, which may be termed the Eastern Grass Veld.

The Sundays River may be taken as its southern boundary, while its northern limit extends to the Tugela River Valley and is continued thence along the north-eastern slopes and foothills of the Drakensberg.

The country on the whole is much dissected by streams and rivers which rise on the Great Escarpment and flow direct to the Indian Ocean. In the south the veld produces many plants which are typical of the Cape, the Karroo and the Karroo boschjes veld, while in the north many tropical forms occur.

The average rainfall throughout the region is between 25 and 40 inches, most of which falls during the summer months, and as both rainfall and temperature increase northwards, the vegetation becomes correspondingly more luxuriant.

The Eastern Grass Veld may be sub-divided into a lower and upper region—The Thorn Veld and the Berg Veld respectively.

The Thorn Veld occupies the country between the coast veld and the foothills of the escarpment up to an altitude of 4,000 ft., while the Berg Veld comprises the vegetation on the eastern slopes of the escarpment from 4,000 ft. upwards. The former is frequently referred to as "sweet veld," while the latter is spoken of as "sour veld."

The dominant grasses in the Thorn Veld are *Eragrostis plana, Sporobolus indicus, Themeda triandra, Andropogon hirtus, A. pertusus, A. amplectens*, and *A. Schoenanthus*.

The thorn bush which gives the country a park-like appearance is chiefly the sweet thorn (*Acacia Karroo*). Other common trees and bushes occurring in the open grass veld are *Acacia caffra, A. Benthami, Dichrostachys nutans, Celastrus laurifolius, Ehretia hottentotica, Trichilia Dregeana, Ptaeroxylon utile, Zizyphus mucronata, Erythrina caffra, Cussonia spicata*, and *Sclerocarya caffra*.

In the sheltered kloofs on the south-eastern slopes of the thorn veld thick bush frequently occurs. Of the larger trees in this bush the chief are *Combretum Kraussii, Calodendron capense, Xymalos monospora, Celtis kraussiana, Pygaeum africanum, Ficus natalensis, Podocarpus Thunbergii*, and *Rhus longifolia*.

Typical and conspicuous succulents in the southern portion of the thorn veld, are the Spekboom (*Portulacaria afra*), the Naabooms (*Euphorbia grandidens* and *E. tetragona*), and the Alwijn (*Aloe ferox*), while the Naaboom (*Euphorbia Tirucalli*), *Aloe Marlothii, Aloe candelabrum* and *Aloe nitens* are characteristic of the northern portion.

The Berg Veld or "Sour Veld" including the Basuto Highlands is characterised by the presence of scattered Protea bush in the grass, and yellow-wood forests in the sheltered kloofs. The chief grasses in the "sour veld" are the Rooi Grass (*Themeda triandra*), *Andropogon ceresiaeformis, Tristachya leucothrix, Trachypogon polymorphus* and *Harpechloa capensis*.

Taller grasses in moist situations are the Tambootie Grasses (*Andropogon nardus* var. *marginatus* and *A. filipendulus*).

Towards the top of the escarpment the grasses tend to grow more in tufts and tussocks than below.

Closely associated with the Proteas in the escarpment are the tree ferns (*Cyathea Dregii*) and Kaffir bread trees (*Encephalartos ghellinchii*).

The chief trees composing the yellow-wood forests are *Podocarpus elongata, P. Thunbergii, Olea laurifolia, Myrsine melanophleos, Rhus lævigata* and *Kiggelaria dregeana*.

In addition to the yellow-wood bush or forest, one of the most conspicuous plant associations in the Berg Veld is the Oudehout (*Leucosidea sericea*) scrub which occurs throughout the Drakensberg range.

The Eastern Grass Veld embraces the most important forests in South Africa, viz., those that are situated on the slopes of the Kaga Berg, the Great Winterberg, and the Amatola Mountains and their foothills. They include the Katberg, Amatola and Perie forests.

These forests are good examples of mixed forests, although the larger portion of the trees are composed of the common and the true Yellow-woods (*Podocarpus elongata* and *Podocarpus Thunbergii*), the latter occurring in the higher regions, the former on the lower slopes of the forest.

Other common timber trees in these forests are the Black Ironwood (*Olea laurifolia*), the Assegai (*Curtisia faginea*), the White Pear (*Apodytes dimidiata*), the White Ironwood (*Toddalia lanceolata*), the Red Currant (*Rhus lævigata*), the Lemon Wood (*Xymalos monospora*), the Thorn Pear (*Scolopia Mundtii*), the Red Els (*Cunonia capensis*), the Red Milkwood (*Minusops oborata*) and Sneezewood (*Ptaeroxylon utile*).

Next in size and importance in this area are the forests of the Transkei, Griqualand East and Pondoland. Chief amongst these are the Zuurberg Forests. They occupy a large belt of country on the Transkeian Zuurberg Range. The forest is very similar in composition to that on the Amatolas, except that the Black Stinkwood (*Ocotea bullata*) is here more frequent.

The forests of Natal and the Transvaal are also confined to the higher slopes of the Drakensberg and differ little in composition from those of the Transkei and Pondoland.

In some of the Transvaal forests the Cabbage Tree (*Anthocleista zambesiaca*) frequently occurs, but it is more abundant in the Low Veld forests of Swaziland.

The Eastern Grass Veld is rich in natural resources. Many valuable timber trees occur in the forests, including the Common and Real Yellow-woods, the Black Ironwood, the Assegai Wood, the White Pear, the White Ironwood, the Red Currant, the Sneezewood, the Black Stinkwood, and the Cabbage Tree.

The "Sweet Veld" is eminently suitable for pasturage, and amongst the pasture grasses occurring in this region may be mentioned:—*Eragrostis plana*, *Eragrostis curvula* var. *valida*, *Themeda triandra*, *Panicum laevifolium*, *Tricholaena rosea* and *T. setifolia*, *Setaria sulcata*, *Pennisetum unisetum*, *Pennisetum Thunbergii*, *Pennisetum sphacelatum*, *Pennisetum typhoideum* and *Sporobolus indicus*.

There are also a number of grasses suitable for paper-making, including the turpentine grass (*Cymbopogon excavatus*), the lemon-scented grass (*Cymbopogon nardus validus*), *Andropogon hirtus*, *Andropogon Schoenanthus*, *A. Dregeanus*, and *Themeda triandra*.

Aloe ferox, *Aloe Marlothii* and *Aloe candelabrum* are valuable as medicinal plants.

A number of plants in the eastern thorn veld have been found to be poisonous to stock, the chief of these are *Crotalaria globifera* and *Crotalaria dura* the cause of Jagtziekte, *Matricaria nigellaefolia* causing bovine staggers, the Natal Slangkop, *Urginea macrocentra*, and the blue and yellow tulps.

4.—The Bush Veld (*Plates VII, VIII*).

The Bush Veld occupies a narrow strip of country which traverses the centre of the Transvaal. It is roughly about 300 miles long and 80 miles broad.

On the north it is bounded by the Waterberg and Pietersburg plateaux, on the south by the Banken Veld and on the east by the angle of the Great Escarpment, while on the west and north-west it merges into the Kalahari and the Low Veld of the

Limpopo Valley. On the whole it is a low-lying tract of country, which has an elevation of 2,500 to 4,000 ft., although in the eastern portion the elevation varies considerably and is some 6,300 ft. on the Lulu range, while at the junction of the Steelpoort and Olifant's River it is only 1,800 ft. above sea level.

The eastern portion consists of broken and hilly country, while the centre is flat and undulating. In the west the general uniformity of the land surface has been interfered with by past volcanic activity of the Pilansberg.

The rainfall varies considerably in this area, and is erratic in its distribution. In the low-lying valleys to the east it is extremely scanty, over the central portion it ranges from 20 to 30 inches per annum, and becomes rather less to the west. The soils throughout are mostly deep and sandy, but large areas are also composed of black "turf" soil, which is typical of this region.

The "turf" usually only supports grass and thorn bush, whereas grass, trees and bush cover the sandy soils. Bush veld is characterised by a fairly uniform growth of bush, which ranges from 15 to 30 ft. in height. As a rule there is considerable space between the trees and bushes, but the country is of such a nature that without a compass it is extremely difficult to find one's way or bearings when surrounded by bush on all sides. The character and composition of the bush varies considerably. Thorn trees dominate the veld throughout, but in the broken country to the east arborescent Nabooms (*Euphorbia ingens* and *E. Cooperi*) are the most characteristic trees. The thorn trees consist chiefly of the Haak-en-steek (*Acacia spirocarpoides*), the Kameeldoorn (*A. Giraffae*), the Haakdoorn (*A. detinens*), the Doornboom (*A. Karroo*), the Aapiesdoorn (*A. Burkei*), the Kaffir Wacht-een-bietje (*A. caffra*), the Ruikpeul (*A. Benthami*), *Acacia hebeclada*, the Sikkelbos (*Dichrostachys nutans*) and the Huilbos (*Peltophorum africanum*).

Other typical trees are the Wilde Sering (*Burkea africana*), the Beukenhout (*Faurea saligna*), the Vaalboom (*Terminalia sericea*), the Maroela (*Sclerocarya caffra*), the Wonderboom (*Boscia Rehmanniana*), the Drolpeer (*Dombeya densiflora*), the Olijvehout (*Olea verrucosa*), the Red Ivory (*Rhamnus Zeyheri*), the Guarri (*Euclea undulata*), the Oliepitten (*Pappea capensis*), the Zuurpruim (*Ximenia americana*), the Respies (*Heeria paniculata*), the Rooibosch (*Combretum Guenzii* and *C. Zeyheri*), the Kiepersol (*Cussonia paniculata*, *C. spicata* and *C. natalensis*), the Blinkblaar wacht-een-bietje (*Zizyphus mucronata*), the Vaalbos (*Tarchonanthus camphoratus*), *Odina discolor*, *Kirkia Wilmsii*, and *Ochna pulchra*.

Typical succulents in this area, apart from the Naabooms (*Euphorbia ingens* and *E. Cooperi*), are *Euphorbia Tirucalli*, *Aloe Marlothii*, *Aloe Wickensii*, *Aloe Pienaarii*, *Aloe globuligemma*, *Aloe Greatheadii*, *Aloe Davyana*, *Aloe castanea*, and *Aloe transvaalensis*.

In the western portion of the Bush Veld, in addition to the thorn trees mentioned above, several species of Kareeboom (*Rhus lancea*, *R. Gueinzii* and *R. incana*) are conspicuous in the veld.

The common grasses of the Bush Veld are *Themeda triandra, Elionurus argenteus, Panicum obscurens, Chloris virgata, Chloris petraea, Panicum laevifolium, Cymbopogon nardus, Cymbopogon plurinodis, Crossotropis grandiglumis, Andropogon hirtus, Andropogon hirtiflorus, Eragrostis superba, Eragrostis brizoides, Eragrostis curvula, Eragrostis chloromelas, Trachypogon polymorphus, Urelytrum squarrosum, Tristachya leucothrix, Triraphis rehmanni, Cymbopogon Ruprechtii, Tristachya rehmanni, Cymbopogon auctus, Pennisetum cenchroides.*

In the Bush Veld timber is obtained from the Aapiesdoorn, the Wilde Sering, the Beukenhout, the Maroola, the Vaalboom, the Drol Peer, and the Red Ivory.

The Berg Bast, the Elandsboontjes, the Doornboom, and the Ruikpeul yield tanning materials.

Fibre is obtained from the Wilde Stok Roos, and from *Triumfetta rhomboidea, Sida rhombifolia* and *Sanseviera Deserti.*

The seeds of the Zuurpruim (*Ximenia caffra*) and the Oliepitten (*Pappea capensis*) are rich in oil.

Excellent grazing and pasturage for stock is provided by the Rooi Grass (*Themeda triandra*), *Sorghum versicolor, Tricholaena rosea, Tricholaena setifolia, Andropogon amplectens, Panicum laevifolium.*

Paper-making material is furnished by the Dek Grass (*Andropogon hirtiflorus*), *Cymbopogon Buchanani, Cymbopogon Dregeanus, Trachypogon polymorphus, Cymbopogon Ruprechtii, Tristachya Rehmanni* and *Cymbopogon auctus*, and valuable gums may be obtained from *Combretum erythrophyllum*, and *Combretum Zeyheri.*

5.—The Banken Veld (*Plate IX*).

In the broken hilly country between the Bush Veld and High Veld is a type of veld which is commonly known as Banken Veld or Banken scenery. It consists mainly of grass covered slopes on which stunted deciduous trees and sclerophyllous bush occur on the rocky outcrops or "banken."

The grasses include many of those which are common to both Bush Veld and High Veld, while the trees and bush consist mainly of the Rooibosch (*Combretum Zeyheri*), the Wilde Sering (*Burkea africana*), the Kaffir Wacht-een-bietje (*Acacia caffra*), the Kiepersol (*Cussonia spicata, C. paniculata* and *C. natalensis*), the Witstinkhout Boom (*Celtis rhamnifolia*), the Guarri (*Euclea lanceolata*), the Witte salie (*Nuxia congesta*), the Klipels (*Plectronia Mundtiana*), the Suikerbos (*Protea abyssinica* and *P. hirta*), the Blinkblaar (*Rhamnus prunoides*), the Olie Pitten (*Pappea capensis*), the Boog (*Croton gratissimus*), the Karee (*Rhus lancea*), the Mispel (*Vangueria infausta*), the Praamdoorn (*Fagara capensis*), the Klapper (*Strychnos pungens*), the Stamvruchte (*Chrysophyllum magalismontanum*), and the Wild Apricot (*Landolphia capensis*).

The common succulents include *Aloe Marlothii, Aloe Davyana, Aloe transvaalensis,* and *Aloe Pretoriensis*, the Honde oor (*Cotyledon orbiculata*), *Kalanchoe thyrsiflora. Euphorbia Schinzii* and *Senecio orbicularis.*

On the whole, the Banken Veld affords poor grazing and pasturage for stock, and the trees and bushes are as a rule too small and stunted to be of much value for timber In some places *Elephantorrhiza Burkei* is fairly plentiful and the bark is eagerly sought after for local tanning purposes. The Bergbast (*Osyris abyssinica*) and the Elandsboontje (*Elephantorrhiza Burchellii*) are also common and are used for tanning.

The Banken Veld abounds in one of the most deadly stock poisons known in South Africa, the Gift-blaar (*Dichapetalum cymosum*), which nearly every spring causes considerable loss amongst cattle.

Other poisonous plants include the Gift-bol (*Buphane toxicaria*), and the Hondeoor (*Cotyledon orbiculata*).

6.—THE HIGH VELD (*Plate X*).

The High Veld includes the southern portion of the Transvaal and practically the whole of the Orange Free State. It is bounded on the north by the Banken Veld, on the east by the Drakensberg Range, on the south by the Upper Karroo, and on the west by the Valleys of the Vaal and Harts Rivers. It is a high-lying tableland whose average height above sea level is between 4,000 and 5,000 ft., with a gentle slope to the west.

The rainfall varies from 35 inches in the eastern portion to 25 or 20 in the western.

Throughout the greater portion of the area the underlying rocks are parallel with the surface, while the soil is mostly deep and of a loamy nature.

The surface is covered with grass, which forms a distinct turf, except towards the western and southern boundaries, where it becomes more open and the grass forms tufts and is often associated with small shrublets. Indigenous trees are entirely absent in this area, except on broken or rocky ground, and along the sides of the streams.

The dominant grass covering the veld is the Rooi Gras (*Themeda triandra*), other common grasses are *Andropogon ceresiaeformis*, *Andropogon amplectens*, *A. hirtiflorus*, *A. schirensis*, *Axonopus semialatus*, *Cymbopogon elegans*, *Digitaria eriantha*, *D. tricholaenoides*, *Panicum natalense*, *P. serratum*, *Eragrostis brizoides*, *E. chalcantha*, *Cynodon Dactylon*, *Tristachya Rehmanni*, *Harpechloa capensis* and *Panicum laevifolium*.

Common shrublets and herbaceous plants which grow amongst the grass are the Elandsboontje (*Elephantorrhiza Burchellii*), *Vigna angustifolia*, *Rhus discolor*, *Pentanisia variabilis*, *Acalypha depressinervis*, *Pachycarpus schinzianus*, *Vangueria pygmaea*, *Pachystigma Zeyheri*, *Gerbera discolor*, *G. piloselloides*, *Berkheya setifera*, *Gazania pygmaea*, *Arctotis scaposa*, *Senecio latifolius*, *S. serra*, *S. coronatus*, *Dimorphotheca spectabilis*, *Helichrysum floccosum*, *Vernonia kraussii*, *V. monocephala*, *V. natalensis*, *Scabiosa Columbaria*, *Becium obovatum*, *Clerodendron triphyllum*, *Ipomaea Greenstockii*, *Gnidia microcephala*, *Erythrina Zeyheri*.

Tuberous and bulbous plants common amongst the grass include *Brachystelma foetidum*, *Raphionacme divaricata*, *Euphorbia truncata*, *Eulophia robusta*, *Buphane toxicaria*, *Gladiolus rigidifolius*, *Hypoxis costata* and *Haworthia tenuifolia*.

The common trees along the streams and rivers are the Doornboom (*Acacia karroo*), the Wilgeboom (*Salix capensis*), and the Vaterlands wilg (*Combretum erythrophyllum*).

The High Veld affords excellent grazing and pasturage for all kinds of stock. The chief pasture grasses are the Rooi Gras (*Themeda triandra*), *Digitaria eriantha*, *Panicum natalense*, *Panicum lævifolium*, *Panicum serratum*, *Tricholaena rosea*, *Tricholaena setifolia*, and *Cynodon dactylon*. Other valuable fodder plants include *Trifolium africanum and Ipomaea Greenstockii*.

The chief poisonous plants of the High Veld are the Tulps (*Homeria pallida*) and *Moraea* spp., which are poisonous chiefly to cattle, and *Pachystigma pygmaea*, which, during certain seasons, causes heavy mortality amongst sheep.

Overstocking on the High Veld invariably results in the veld becoming overrun with *Stoebe cinerea*, which crowds out the pasture grasses.

7 AND 8.—THE WATERBERG SAND VELD (*Plate IV*) AND THE PIETERSBURG HIGH VELD.

The Limpopo Highlands as delimited by Rogers include the high-lying country which lies to the north and east of the northern extension of the Drakensberg. They comprise the Waterberg, Pietersburg, and Zoutpansberg plateaux, with their surrounding country. Three distinct plant regions are recognisable: (1) A western portion, which may be called the *Waterberg Sand Veld*, occupied mainly by the Waterberg plateau is, on the whole, hilly and rugged country with scanty and sandy soil. The sandy valleys are mostly covered with grass, in which *Elionurus argenteus*, *Eragrostis superba*, and tall species of *Andropogon* are common, while the dominant trees are the Beukenhout (*Faurea saligna*) and Suikerbos (*Protea abyssinica*) on the stiff close-grained soils and the Vaal boom (*Terminalia sericea*) on the deep, loose, sandy soils. The deadly Giftblaar (*Dichapetalum cymosum*) is extremely plentiful in this region and is nearly always associated with the Wilde Sering.

(2) An eastern portion, comprising the Pietersburg plateau, and which may be termed the Pietersburg High Veld, consists chiefly of flat rolling country, which resembles typical High Veld scenery, and on which the Rooi Grass (*Themeda triandra*) dominates. To the south the plateau slopes away to the Bush Veld, and as soon as the altitude drops to 3,000 ft., grass and vegetation gives way to bush.

To the north the grassveld of the Pietersburg plateau merges into the thorn veld of the low country of the Limpopo Valley. It is characterised by the dominance of *Acacia pallens*, *A. spirocarpoides*, *A. karroo* and *Combretum porphyrolepis*.

(3) The northern portion of the Zoutpansberg plateau, which is composed of parallel ranges of sandstone, lies at a lower altitude than the Waterberg and Pietersburg plateaux. The vegetation is similar to that of the Low Veld, and from a phytogeographical point of view may be included in the latter region.

9.—The Griqualand West Thorn Veld (*Plate XI*).

In the centre of the inland plateau and bounded on the south by the Orange River, on the west by the Kalahari, and on the east by the High Veld, is a somewhat triangular block of country which is usually included under the term "The Kaap Plateau." Botanically this region is perhaps less known than any other part of the inland plateau, but from what little information is available, its affinities undoubtedly lie with the western portion of the plateau rather than with the eastern.

The whole area falls naturally into three distinct types of veld. The eastern portion consists of long, open river valleys (the valleys of the Dry Harts, Harts and Vaal Rivers), with deep alluvial soils and gravels, which are covered with a park-like growth of thorn trees and tufted grasses. This I shall describe as the Griqualand West Thorn Veld.

The central portion, the Kaap Plateau proper, consists of an extensive dolomite and limestone plateau of shallow soils which are covered with bush, xerophytic shrubs and shrublets. This I shall refer to as the Kaap Plateau Bush Veld.

Between the Kaap Plateau Bush Veld and the Kalahari is a tract of undulating veld composed of stony and rocky hills, sandy plains and dry river valleys. The hills are covered with bush and scrub, the sandy plains with grass and the Vaal Kameel Thorn, while the low-lying valleys contain many brak and xerophytic shrublets. This tract of country I have included under the title "The Vaal Kameel Veld of the Asbestos Mountains."

The Griqualand West Thorn Veld includes the valleys of the Orange, Vaal, Harts and Dry Harts Rivers lying in the districts of Herbert, Kimberley, Barkly West, Bloemhof, Taungs, and Vryburg.

The veld is park-like throughout. This type of scenery is produced by various thorn trees growing amongst Karroo bush and grass in the south, but chiefly amongst grass only in the north.

The common thorn trees are the Haak-en-steek (*Acacia spirocarpoides*), the Kameeldoorn (*Acacia Giraffae*), the Doornboom (*Acacia Karroo*), the Haakdoorn (*Acacia detinens*) and the Terassibos (*Acacia stolonifera*).

Other typical trees, bushes, and shrublets found in this veld are the Witgats (*Boscia albitrunca* and *Boscia transvaalensis*), the Vaal Bos (*Tarchonanthus camphoratus*), the Blauwbosch (*Royena pallens*), the Driedoorn (*Rhigozum trichotomum*), the Zuur-karree (*Rhus ciliata*), the Rozijntjebosch (*Grewia cana*), the Bitterbossie (*Chrysocoma tenuifolia*), the Schaap Bos (*Pentzia incana*), and the Harpuis-bos (*Euryops multifidus*).

Typical and dominant grasses are *Schmidtia bulbosa*, *Chloris virgata*, *Eragrostis lehmanniana*, *Aristida adscensionis*, *Eragrostis*

truncata, *Panicum Marlothii*, *Themeda triandra*, *Eragrostis denudata*, *Anthephora pubescens*, *Fingerhuthia africana*, *Panicum Holubii*, *Eragrostis superba*, *Aristida congesta*, *A. brevifolia*, *A. Burkei*, *A. uniplumis*, *A. stipiformis*, *A. mollissima*, *Pogonarthia falcata*, *Tragus koelerioides*, and *Chrysopogon serrulatus*.

Other characteristic plants occurring in this region are the Wilde Kalabas (*Hibiscus urens*), the Wild Senna (*Cassia oborata*), the Cape Slangkop (*Ornithoglossum glaucum*), the Slangkop (*Urginea Burkei*), the Dubbeltjedoorn (*Tribulus terrestris* and *T. zeyheri*), the Stijfziekte Bos (*Crotalaria Burkeana*), the Gousblom (*Gazania uniflora*), the Pakkiesblom (*Hermannia brachypetala*), the Duiveltjes (*Pretrea zanguebarica*), the Kriedoon (*Lycium tetrandrum*), and the Vomeerbossie (*Geigeria passerinoides*).

Tulps are extremely plentiful and often give the veld a blue or yellow hue due to *Moraea polystachya* and *Homeria pallida*.

The chief succulents are *Aloe grandidentata* and *Aloe Schlecteri* var. *Orpeniae*.

The pasture and hay grasses of the Griqualand West Thorn Veld are practically the same as those found on the Kaap plateau. One of the most important poisonous plants is *Ornithoglossum glaucum*, the Cape Slangkop. *Lebeckia psiloloba* is suspected of poisonous properties, and *Tribulus terrestris*, under certain conditions, produces Geel dik-kop in sheep.

In the thorn veld of the Harts River Valley, *Acacia Giraffae* is plentiful and the pods of this tree provide an excellent stock food.

10.—The Kaap Plateau Bushveld (*Plates XII, XIII*).

The Kaap Plateau Bushveld occupies the wide limestone plain which stretches from a little south of Griquatown to the north of Vryburg. On the east it is bounded by the escarpment of the Campbell Rand, which overlooks the valleys of the Vaal and the Harts Rivers, and on the west by the Asbestos and Kuruman Hills.

The whole area is remarkably flat, and is characterised by the presence of numerous pans, whose floors are composed of tufaceous limestone. The surface of the ground is hard and uneven and consists very largely of dolomite outcrop. Here and there, however, soil of a sandy nature occurs.

The plateau throughout is covered by bush or scrub which ranges in height from 6 to 15 ft. This bush is composed mainly of the Olijvehout (*Olea verrucosa*), the Zuurkaree (*Rhus tridactyla*), the Haakdoorn (*Acacia detinens*) and the Vaalbos (*Tarchonanthus camphoratus*). The Haakdoorn is dominant in the south, the Olijvehout and Zuurkaree in the central portion, and the Vaalbos in the north.

Karroo bush, composed of *Chrysocoma tenuifolia* and *Pentzia incana*, is mainly associated with the Haakdoorn, the Olijvehout and the Zuurkaree on the shallow dolomite outcrops, while grass veld is more commonly associated with the Vaalbos where the soil is sandy and deeper.

The dominant grasses are the Rooi Gras (*Themeda triandra*), *Eragrostis lehmanniana*, and *Aristida* spp.

Often associated with Olijvehout and the Zuurkaree are large trees of the Kareeboom (*Rhus viminalis*) and the Blinkblaar wacht-een-bietje (*Zizyphus mucronata*).

The blue tulp (*Moraea polystachya* var. *brevicaulis*) is extremely common throughout the plateau, as well as the Transvaal Slangkop *Urginea Burkei*. The latter is nearly related to the European plant producing "squills" and may be of equal medicinal value. *Crotalaria Burkeana* is prevalent in this region, and is the cause of Stijf-ziekte in cattle. The Vermeer-bosje (*Geigeria passerinoides*) is another well-known poisonous plant in this area.

The most important timber trees are the Wild Olive (*Olea verrucosa*), the Transvaal Beukenhout (*Faurea saligna*), and the Transvaal Kajatenhout (*Peltophorum africanum*). Large tracts of country are covered with *Euryops multifidus*, a plant which is becoming a pest to stock farmers, as it is crowding out the pasture grasses, but which yields a resin which might be exploited commercially.

The principal pasture and hay grasses in this region are *Eragrostis lehmanniana*, *Schmidtia bulbosa*, *Themeda triandra*, *Eragrostis brizoides*, *E. obtusa*, *E. superba*, *E. chalcantha*, *Chrysopogon serrulatus*, *Anthephora pubescens*, *Digitaria eriantha* and *Fingerhuthia africana*.

11.—The Vaal Kameel Veld of the Asbestos Mountains (*Plates XIV, XV*).

The Vaal Kameel Veld of the Asbestos Mountains includes the strip of country from the Asbestos Mountains and Kuruman hills on the east to the Langeberg and Kalahari in the west. The Asbestos Mountains are low-lying and rounded hills which rise about 1,000 ft. above the surrounding country. The surface soil on the hills is reddish and is covered with small flat loose stones. Along the foothills of the mountains there is frequently a belt of deep red sand. Between the Asbestos and Langeberg ranges the soil is also mostly deep red sand, but in the northern portion of this area there is a small limestone plain similar to that on the Kaap Plateau. This also has numerous pans, and the veld closely resembles that on the Kaap Plateau in composition and scenery.

The Asbestos hills are covered with scrub which varies in height from 3 to 10 ft. The scrub is composed mainly of the Ijstervarkbos (*Lebeckia macracantha*), the Vaalbos (*Tarchonanthus camphoratus*), the Zuurkaree (*Rhus tridactyla*), the Olijvehout (*Olea verrucosa*), the Haakdoorn (*Acacia detinens*), the Terassibos (*Acacia stolonifera*), the Blinkblaar wacht-een-bietje (*Zizyphus mucronata*), the Klapper Bos (*Nymania capensis*) and the Driedoorn (*Rhigozum trichotomum* and *R. obovatum*).

Other common plants occurring on these hills are the Bitter Karroo (*Chrysocoma tenuifolia*), the Schaapbos (*Pentzia incana*), the Wild Senna (*Cassia obovata*), the Vermeerbossie (*Geigeria passerinoides*), the Cape Slangkop (*Ornithoglossum glaucum*), and *Sesamum capense*.

The sandy belts along the foothills are, after rain, covered with a luxuriant growth of grass, which is composed mainly of *Eragrostis lehmanniana, E. superba, Anthephora pubescens* and *Aristida* spp. Scattered through this sandy grass veld are numerous trees of the Vaal Kameel thorn (*Acacia haematoxylon*) which range in height from 10 to 15 ft., and often give the veld a dull glaucous grey appearance.

In the plains and valleys Karroo bush (*Chrysocoma tenuifolia* and *Pentzia incana*) and shrublets of Harpuis (*Euryops multifidus*) and Kapokbossie (*Eriocephalus pubescens*) dominate the veld, while scattered trees of Kameeldoorn (*Acacia Giraffae*), Vaal Kameel (*A. haematoxylon*), Haakdoorn (*Acacia detinens*), Witgat (*Boscia albitrunca*), Vaalbos (*Tarchonanthus camphoratus*), Blinkblaar wacht-een-bietje (*Zizyphus mucronata*), and Kriedoorn (*Lycium* spp.) occur throughout.

Towards the north of the limestone plateau almost park-like scenery is produced by bushes or trees of the Olijvehout, the Zuurkaree, the Haakdoorn and the Vaalbos. Grass is almost entirely absent from the limestone plateau, where its place is taken by Karroo bush. On the western edge of the plateau large Witgat trees (*Boscia albitrunca*) form a conspicuous feature in the veld.

The low-lying portions of the sandy veld between the Asbestos Mountains and the Langeberg range are characterised by the prevalence and abundance of brak plants, while grass only occurs on the well drained sandy slopes.

The vegetation on the Langeberg range differs from that of the Asbestos, in that it is covered with bush or scrub from about 6 to 10 ft. high, in which bushes of *Croton gratissimum* dominate. Associated with this are bushes of *Rhus tridactyla, Grewia flava,* and *Tarchonanthus camphoratus,* in fact the Vaalbosch (*Tarchonanthus camphoratus*) often dominates the vegetation on the top of the range, while *Croton gratissimus* is dominant on the mountain slopes.

A great variety of grasses occur on the Langeberg, chief amongst which are:—*Digitaria eriantha, Panicum maximum, Chloris petraea, Panicum nigropedatum, Sporobolus fimbriatus, Enneapogon mollis, Pennisetum cenchroides, Heteropogon contortus, Eragrostis gummiflua* and *Aristida* spp.

12.—The Kalahari Sand Veld (*Plate XVI*).

North of the Orange River and separating the South-West Protectorate from the Union of South Africa is a large stretch of sandy country lying at an altitude of 2,000 to 3,000 ft. It includes the greater portion of the districts of Gordonia, Kuruman and Vryburg. This area is the southern portion of the great Kalahari region, and as it just falls within the scope of this review, I shall refer to it as the Kalahari Sand Veld. It is covered with deep sand throughout, which is in the greater part of the area thrown up into long dunes which lie in a west-north-west direction.

Unlike the adjoining region of Bushmanland, the vegetation here is much more pronounced and conspicuous; instead of small stunted shrubs, the Kalahari often supports a growth of well-developed trees, amongst which the Camel Thorn dominates, and under which a luxuriant growth of various grasses is usually found.

The majority of the dunes are covered with coarse grass,—the Pijpgras,—amongst which scattered "Witgat" trees (*Boscia rehmanniana*, *B. albitrunca* and *B. Pechuelii*) are dotted about. Some of the more common grasses in this veld are *Eragrostis superba*, *Eragrostis denudata*, *Eragrostis pallens*, *Aristida uniplumis*, *Aristida stipiformis*, *Aristida mollissima*, *Schmidtia bulbosa* and *Anthephora pubescens*, while the low-lying sandy plains with internal drainage support only a scanty growth of brak plants, such as the Brak bos (*Atriplex Halimus*), the Brak Ganna (*Salola aphylla*), the Kapokbossie (*Eriocephalus umbellatus*) and the Harpuis bos (*Euryops multifidus*).

The fact of the presence of numerous brak plants in this region has an important bearing on Prof. Schwarz's Kalahari scheme. Even if it were possible to irrigate the Kalahari, this ground would be useless for agricultural purposes, as wheat and similar crops will not grow in a brak soil.

One of the most characteristic plants of certain parts of this sand veld is the Tsamma (*Citrullus vulgaris*), a melon which furnishes a valuable stock food in times of drought.

13.—The Damaraland Thorn Veld (*Plate XVII*).

In the north-west corner of the inland plateau dealt with within the scope of this address are situated the Highlands of Central Damaraland, which consist of rugged mountainous country with an average rainfall of 15 inches.

The vegetation is fairly uniform throughout and may be described as the Damaraland Thorn Veld.

It is essentially a thorn scrub made up of bushes and trees which range from 10 to 20 ft. in height and is composed of Haakdoorn (*Acacia detinens*), *Acacia Maras*, *Acacia heteracantha*, *A. dulcis*, the Sikkelbos (*Dichrostachys nutans*), the Vaalbos (*Tarchonanthus camphoratus*), the Witgat (*Boscia Pechuelii*) and *Combretum apiculatum*.

Common succulents in this scrub, especially on the steep hill slopes, are *Aloe rubrolutea*, *A. hereroensis* and *Senecio longiflorus*.

In the dry river valleys the trees attain a great size, and consist chiefly of the Kameeldoorn (*Acacia Giraffae*), the Doornboom (*A. karroo*), the Blinkblaar-wacht-een-bietje (*Zizyphus mucronata*), *Combretum primigenum* and *Acacia hebeclada*. On the open sandy flats the Stinkbosch (*Boscia foetida*), Kriedoorn (*Lycium* spp.) and *Cataphractes Alexandri* often dominate the veld.

Towards the east the thorn scrub merges into the Kalahari, where the Haakdoorn becomes the dominant bush.

14.—The Cameel Thorn Veld of Southern Damaraland (*Plate XVIII*).

Occupying a comparatively small tract of country in Southern Damaraland, a type of veld is found very different from that which occurs in the adjoining region to the south, in Great Namaqualand.

Instead of low xerophytic bush and scrub, a distinct park-like or even forest type of scenery prevails. This type of veld coincides very closely with that part of the country which is commonly known as Bastardland. It consists of deep sandy flats well covered with high trees and grass. The dominant tree is the Kameeldoorn (*Acacia Giraffae*), which is responsible for giving the country the appearance of being densely wooded. Other common thorn trees and bushes in this veld are the Doornboom (*Acacia Karroo*), the Haakdoorn (*Acacia detinens*), the Terassi Bos (*Acacia stolonifera*), and *Acacia hebeclada* and the Kriedoorn (*Lycium* sp.)

The grass is mainly *Aristida ciliata* and other species of the same genus. On the southern outskirts of this Camel Thorn Veld, where the soil is a little shallower, the veld is composed of grass in which stunted Haakdoorn bushes and large Witgat (*Boscia albitrunca* and *B. Transvaalensis*) trees are scattered about.

15.—The Cape Veld or South Western Veld (*Plate XIX*).

Occupying a narrow angular strip of country in the extreme south-west corner of the Cape Province is a type of veld unlike that in any other part of South Africa. To botanists the region has long been known as the South Western Region of the Cape Province. For the purposes of this address I shall refer to it as "The Cape Veld."

It is the best known botanically of all the types of veld in South Africa, and has been very fully described by such able botanists as Bolus and Marloth, so that it will not be necessary for me to do more than describe in the briefest manner its most salient features.

Its north-western arm extends as far as the Bokkeveld Mountains, with outliers on the Kamiesberg, while its eastern extension reaches to the Sundays River Valley and includes the forests of George and Knysna. On the north it is bounded by the Karroo, although islands of typical Cape Veld occur in the Karroo along the tops of the mountain ranges such as Zwartebergen, Wittebergen, etc.

The country on the whole is very mountainous, the mountains being rugged and bare.

On the mountain slopes, valleys and sandy flats, the veld is composed of stunted bushes and shrubs which range in height from 3 to 6 ft. The dominant and most typical bush throughout the region is the Rhenoster Bush (*Elytropappus rhinocerotis*).

The average annual rainfall is about 29 inches, most of which falls during the winter months.

Along the coast the common plants are *Salicornia fruticosa*, *Chenolea diffusa*, *Statice scabra*. Grasses are very few in number, the most typical are *Stenotaphrum glabrum* and *Eragrostis*

glabrata. Further inland on the sand dunes, common grasses and sedges include *Eragrostis cyperoides*, *Sporobolus pungens*, *Agropyrum distichum* and *Scirpus nodosus*. Common stunted shrubs and bushes occupying the dunes are the Waxberry (*Myrica cordifolia*), the Dronkbossie (*Chymococca empetroides*), the Duinebossie (*Mundtia spinosa*) and the Kraaiebossie (*Rhus crenata*).

Typical of the low bush or scrub on the sandy flats are the Kersebos (*Euclea racemosa*), the Schaapbostee (*Psoralea bracheata*), the Suikerbossies (*Protea mellifera* and *P. scolymocephala*), the Kreupelhout (*Leucospermum conocarpum*), the Blombos (*Metalasia muricata*), the Gouty Geranium (*Pelargonium gibbosum*), the Bozemriet (*Restio eleocharis*), *Carex arenaria*, *Eragrostis spinosa*, *Eragrostis cyperoides*, and *Ammophila arundinacea*.

In the inland valleys and plains where the Rhenoster Bush (*Elytropappus rhinocerotis*) dominates the veld, the Kapokbossie (*Eriocephalus umbellatus*), the Harpuisbos (*Euryops tenuissimus*), the Doornbos (*Metalasia muricata*), the Slangbos (*Stoebe cinerea*), the Cape Sumach (*Colpoon compressum*) the Langeleden (*Polygala myrtifolia*), and the Bos-ijzerhout (*Dodonea Thunbergiana*) are also frequent.

Typical plants occurring in vlei ground are the Palmiet (*Prionium serratum*), the Varkblom (*Zantedeschia aethiopica*) and the grass (*Pennisetum macrourum*).

On the mountain slopes composing what is commonly referred to as the Macchis, are the Silver trees (*Leucadendron argenteum*), the Suikerbossies (*Protea mellifera*, *P. lepidocarpodendron* and *P. neriifolia*), the Olijvehout (*Olea verrucosa*), the Krentebos (*Rhus tomentosa*), the Mirting (*Myrsine africana*), the Waaboom (*Protea grandiflora*), the Kreupelhout (*Leucospermum conocarpum*), the Tolbos (*Leucadendron plumosum*), the Rooi Stompie (*Mimetes lyrigera*), the Bakbos (*Passerina filiformis*), the Wilde Malfa (*Pelargonium cucullatum*) and *Aspalathus chenopoda*.

The forests of George, Knysna, and Humansdorp lie within the South-Western or Cape Veld. They flank the Outeniqua and Zitzikamma Mountains and form a continuous belt which is roughly 100 miles long by 10 miles broad. The forests are composed mainly of Black Stinkwood (*Ocotea bullata*), the Yellow-woods (*Podocarpus elongata* and *P. Thunbergii*), the Rooi Els (*Cunonia capensis*), the Black Ironwood (*Olea laurifolia*), the Vlier (*Nuxia floribunda*), the Assegaiwood (*Curtisia faginea*), the Witte Els (*Platylophus trifoliatus*), the White Pear (*Apodytes dimidiata*), the Kersehout (*Pterocelastrus variabilis*), the Kamassihout (*Gonioma Kamassi*) and the Coalwood (*Lachnostylis capensis*).

They are distinguished from the eastern forests by the abundance of the Keurboom (*Virgilia capensis*), which is typical of the South-Western Veld. The Zitzikamma forests are also characterised by an abundance of the Stokroos (*Sparmannia africana*) which yields a valuable fibre.

The remnants of a larger forest, which was apparently similar in composition to that of the Knysna, still exist on the rocky slopes of the Langeberg near Swellendam.

On the west coast the Clanwilliam Cedars (*Widdringtonia juniperoides*) occur on the Cedar Berg Mountains. These mountains also produce the well-known Buchu (*Barosma betulina*) of commerce.

Among the poisonous plants in this region may be mentioned *Lessertia annularis*, the Klimop (*Cynanchum capense*), the Chinkerchee (*Ornithogalum thyrsoides*), various species of blue and yellow tulps (*Moraea* and *Homeria* spp.), and several introduced plants. One of these, *Datura stramonium*, which has established itself as a weed almost all over the country, is a valuable drug plant.

Elytropappus rhinocerotis is a very common and usurping weed of the grazing veld, its inroads being largely due to overstocking and burning the veld.

16.—THE KARROO (*Plates XX, XXI*).

The Karroo embraces the low-lying stretch of country which lies immediately south of the southern portion of the Great Escarpment.

The valleys of the Sundays River in the east and the Olifants River on the west may be taken as approximately its eastern and western limits. To the south it is intersected and bounded by the Cape Ranges. It varies considerably in altitude from 1,000 ft. in the central portion to 4,000 ft. above sea level in the west.

The average annual rainfall also varies from under 5 inches in the west to 15 inches in the central and eastern portions. In the west the greater part of the rain falls during the winter months, whereas the summer rainfall increases from the central portion eastwards.

The Karroo is a country of shallow soils and rock-strewn surfaces, consequently, when rain does occur, the run-off is extremely rapid.

The country is devoid of trees except along the dry river courses, where a few thorn trees and kameelbooms usually occur. Grass is also almost entirely absent.

The vegetation is largely composed of succulents, xerophytic shrubs and shrublets.

The Karroo may be divided into four main regions: (1) The Great Karroo or Central Karroo; (2) The Western or Ceres Karroo; (3) The Little Karroo, and (4) The Robertson Karroo.

The Great or Central Karroo includes the Ghoup, Moordenaars Karroo, and the Eastern Karroo.

The vegetation in the Ghoup is composed mainly of small bushes and shrublets, amongst which *Rhigozum obovatum* usually dominates, with it are commonly associated *Lycium arenicolum*, several species of *Pelargonium* (*P. munitum*, *P. carnosum*, and *P. crithmifolium*) and the Bushman's Candle (*Sarcocaulon Burmanni*). The Karroo bush, *Pentzia virgata*, and the Kraal Bosch (*Galenia africana*) are also often dominant over large areas.

In Moordenaars Karroo, shrubby Mesembrianthemums (*M. spinosum* and related species) practically dominate the vegetation.

The Eastern Karroo is characterised by the presence of *Aloe ferox, Pentzia virgata,* and an abundance of a number of succulent species of *Euphorbia,* amongst which the Noorse (*E. coerulescens*) is often the dominant plant, as in the Jansenville district and Sundays River Valley.

Whenever the soil is inclined to be brackish, the Ganna bosch (*Salsola aphylla* and *S Zeyheri*) takes possession of the veld.

The vegetation in the central portion of the Great Karroo is composed mainly of succulent *Mesembrianthemums* which take on a more or less cushion-like form of growth. These include *Mesembrianthemum calamiforme, M. felinum,* etc.

The Western or Ceres Karroo includes the Bokkeveld and Tanqua Karroos, which are the driest parts of this region. The Kraalbos (*Galenia africana*) and the Geel Melkbos (*Euphorbia mauritanica*) cover extensive areas and entirely dominate the veld.

The Little Karroo comprises the country surrounding Ladismith and Oudtshoorn. To the north it is bounded by the Zwarte Berg range and on the south by the Lange Berg and Outeniquas Mountains.

The vegetation in the Little Karroo is more pronounced and more varied than the Great Karroo. It harbours a number of the most interesting plants found in South Africa. In the western portion, which includes the valley of the Touws River, one of the distinguishing features of the veld is the presence of the Guarri Bush (*Euclea undulata*) both on the plains and on the hill slopes. Closely associated with the Guarri Veld are bushes and trees of the Wilde Pruimen (*Pappea capensis*) and the Boer-boon (*Schotia speciosa*). In addition to this tree and bush growth the veld is covered on the flats with an extensive growth of shrubby Vijgebossies (*Mesembrianthemum spp.*), Gannabos (*Salsola aphylla*), Kraalbosch (*Galenia africana*), and Witbossie (*Pteronia pallens*).

On the hill slopes the vegetation is much more varied. The most typical plant associations include the Boterboom (*Cotyledon fascicularis*), Plakkies (*Crassula portulacca*), the Geel Melkbos (*Euphorbia mauritanica*), the Rooi Alwijn (*Aloe microstigma*), *Crassula perfossa* and *Sarcocaulon spp.*

The vegetation on the plains and valleys in the eastern portion of the Little Karroo is of much the same type as that in the west, but the Vijgebossies (*Mesembrianthemum spp.*) more often than not entirely dominate the veld, while the Bitter Alwijn (*Aloe ferox*) and the Spekboom (*Portulacaria afra*) become more and more prominent on the hill slopes towards the east.

Situated just beyond the south-west corner of the Little Karroo is a small island of Karroo Veld commonly known as the Boschjes Veld. This is now usually referred to as the Robertson Karroo.

Its original name at once indicates the general nature of the vegetation which is here more luxuriant than in other parts of the Karroo. The bushes are composed chiefly of the Guarri (*Euclea undulata*), the Bos-ijzerhout (*Dodonaea Thunbergiana*), the Boer-boon (*Schotia speciosa*), and the Num-num (*Carissa*

Arduina), while the succulents are represented by the Boterboom (*Cotyledon fascicularis*), the Honde Oor (*Cotyledon orbiculata*), the Plakkies (*Crassula portulacea*), the Geel Melkbos (*Euphorbia mauritanica*), and Vijgebossies (*Mesembrianthemum blandum* and *M. junceum*).

On the more open ground the Kraalbos (*Galenia africana*) and the Karroo-bossies (*Pentzia incana* and *Chrysocoma tenuifolia*) dominate.

The northern part of the whole region is naturally invaded here and there by typical Upper Karroo plants amongst which the Doornvijgbos (*Mesembrianthemum spinosum*) is perhaps the most prevalent; on the other hand, the southern borders of the Karroo are frequently encroached upon by plants from the Cape region, especially is this the case with the hill-tops, which carry typical Cape vegetation, while the hill slopes and high-lying plains are frequently covered with the Rhenoster bush (*Elytropappus rhinocerotis*).

17.—The Upper Karroo (*Plate XXII*).

In this region Rogers includes the south-west portion of the Orange Free State, the valley of the Vaal River south of Barkly West and that part of the Cape Province between the Great Escarpment on the south and Bushmanland and the Orange River on the north. Bolus adopted a very similar area for his Upper Region. Marloth divided this area into a southern portion, the Karroid Plateau, a north-west portion known as Bushmanland, and a south-eastern portion, a part of the Bush Veld.

For purposes of a plant survey, two distinct areas can be recognised; the southern portion, the Upper Karroo, the greater part of which lies at an altitude of 4,000 to 5,000 feet, and which is bounded on the north by the Langebergen, the Kubiskow Range and the Karreebergen; and a northern portion, which is known as Bushmanland, which I prefer to include with the Kokerboom Veld of Namaqualand.

The Upper Karroo is made up mostly of rocks of Karroo sediments; it is a monotonous country, but broken with hills, and the surface of the soil is covered with loose stones and boulders. The vegetation consists of short shrublets, not more than about 18 inches high, and these are chiefly Karroo Bush and shrubby *Mesembrianthemums*.

18.—The Kokerboom Veld of Namaqualand and Bushmanland (*Plates XXIII—XXV*).

Occupying the greater portion of the western edge of the interior plateau is a large tract of variable country which may be described as "The Kokerboom Veld of Namaqualand," in which the Kokerboom, *Aloe dichotoma*, is the most characteristic plant.

In the south it includes the rocky country in the neighbourhood of the Kamiesberg, the mountains of Little Namaqualand, the Richtersveld, the Valley of the Orange River as far east as Prieska, and practically the whole of Great Namaqualand north of the Orange River, which lies between the Escarpment on the west and the Kalahari region on the east. Apart from the

mountainous districts in the south-west corner, and the Valley of the Orange River, the country is one of table-landscapes and vast plateaux and plains. Semi-desert conditions prevail throughout, and with the exception of the Orange and part of its chief tributary, the Great Fish River, the river beds and water-courses are dry throughout the greater part of the year.

The rainfall over practically the whole area is under 10 inches, most of which falls during the winter months.

The region as a whole may be described as one of vast arid and stony wastes.

The rocky mountains in the south-west corner of the region, except for the presence of the Kokerboom and a few succulents, are almost bare and destitute of vegetation.

The high plateaux to the east of the western escarpment are covered with grass, which is mostly short, of a tufted habit, and does not form a uniform covering, but leaves bare spaces between the individual plants. The chief grasses on these high plateaux are *Aristida dregeana*, *Aristrida obtusa*, and *Aristida subacaulis*.

As companions to the grass are isolated bushes of Driedoorn (*Rhigozum trichotomum*) and a few succulents such as the Bushman's Candle *Sarcocaulon Burmanni*) and *Euphorbia namibensis*.

Further east, on the sandy plains, lying at the foothills of the high plateaux, a rather different type of grass flora is frequently met with. Here the plains are covered with the Toa Grass (*Aristida brevifolia*) which has a much more tufted or even bushy habit.

The greater portion of the country to the east, which lies at an elevation of 3,000 to 4,000 ft. above sea level and consists mostly of vast undulating and stony plains, only broken here and there by the presence of dolorite kopjes, is clothed with a scanty covering of xerophytic shrubs, the chief of which are *Parkinsonia africana*, the Haakdoorn (*Acacia detinens*), the Nonnie Bosch (*Boscia foetida*), *Cataphractes Alexandri*, the Driedoorn (*Rhigozum trichotomum*), *Zygophyllum morgsana*, *Hermannia spinosa*, and the Ngaap (*Hoodia Gordoni*).

The latter is one of the most characteristic succulents on the flat sandy plains in Great Namaqualand.

Further east, where the plains of Great Namaqualand merge into the Kalahari region, and the area is one of internal drainage, there are vast extensive flats, which only support a growth of Ganna (*Salsola aphylla*) bush, indicating the brackish nature of the soil. In the low-lying valleys, which are below 3,000 ft. in altitude, the Aggennys Euphorbia bush (*E. gregaria*) is nearly always dominant, and is usually associated with bushes, shrubs. and shrublets of *Parkinsonia africana*, *Acacia detinens*, *Boscia foetida*, *Cataphractes Alexandri*. *Rhigozum trichotomum* and *Pteronia glauca*. Various species of *Aristida* grass also occur here.

In the Orange River Valley the character of vegetation is more pronounced than elsewhere. Along the edge of the river the dominant trees and shrubs are *Salix capensis*, *Zizyphus*

mucronata, *Euclea Pseudebenus*, *Combretum erythrophyllum*, *Acacia karroo*, *A. Giraffae*, *Rhus viminalis*, *Royena pallens*, *Tamarix articulata*, and *Nicotiana glauca*, while *Phragmites communis* is common.

On the rocky slopes in the river valley, the Kokerboom (*Aloe dichotoma*), the Gift-boom (*Euphorbia virosa*) and the peculiar *Pachypodium namaquanum* occur.

In the gentle valleys leading to the river the Aggennys Euphorbia is dominant, and the Kraalbos (*Galenia africana*) is very plentiful.

Along the dry river beds and valleys in the interior the vegetation is composed mainly of the Camel Thorn (*Acacia giraffae*), the Sweet Thorn (*Acacia Karroo*),the Black Ebony (*Euclea pseudebenus*), the Oliepitten (*Pappea capensis*), the Nonnie Bosch (*Boscia foetida*), the Haakdoorn (*Acacia detinens*), the Tamarisk (*Tamarix articulata*), *Zygophyllum prismatocarpum*, *Z. simplex*, *Z. microcarpum*, *Z. cylindrifolium*, *Lycium namaquense*, *Galenia africana*, and *Salsola aphylla*.

Physiographers usually regard Bushmanland and the Kalahari as one region.

Bushmanland is one of the most arid parts of the inland plateau, its annual rainfall is less than 5 inches, part of which falls during the winter months, whereas the annual rainfall on the Kalahari varies from 10 to 20 ins., most of which falls during the summer months. In consequence there is a considerable difference in the general aspect of the vegetation found in these two areas, and for this reason they may well be treated separately.

Bushmanland is bounded on the west by the southern extension of the Namaqualand Highlands, which includes the Kameesberg and the mountains of Little Namaqualand, on the north by the valley of the Orange River, on the east by the Kaap Plateau and Kaap Valley, and on the south by the Upper Region.

It is essentially a country of sandy plains, undulating and featureless.

In the central portion there are numerous salt-water pans, while isolated rocky hills of the "Inselberg" type occur here and there. The average height of the country varies from 2,000 to 3,500 ft., towards the north the surface slopes fairly uniformly towards the Orange River. The vegetation throughout is sparse and scanty, and consists mainly of shrubs and shrublets which do not exceed 3 ft. in height.

After rain the Toa grass and Bushman grass are plentiful.

The dominant shrub on the red sandy plains is the Driedoorn (*Rhigozum trichotomum*); with this are associated stunted bushes of *Parkinsonia africana*, *Hermannia pulchella*, *Hermannia grandiflora*, *Cataphractes Alexandri*, *Boscia foetida*, *Cadaba juncea*, *Zygophyllum* spp., and *Bauhinia garipensis*.

Common succulents on the rocky outcrops, are *Aloe dichotoma*: and *Sarcocaulon Burmanni* and *Hoodia Gordoni* on the sandy plains.

The chief grasses are *Aristida adscensionis* Linn., *A. vestita*, Thunb., *A. ciliata*, *A. namaquensis*, *A. obtusa* Del., *Eragrostis spinosa* Trin., and *Enneapogon scaber*, Lehm.

19.—The Western Littoral or Namib (*Plates XXVI-XXVIII*).

In striking contrast to the vegetation on the east coast, that on the west is more scanty and desert-like than any other part of the sub-continent. This desert region may be described as the Western Littoral or Namib. It reaches from the Olifants River in the south to beyond the limits of our northern boundary. It is a narrow coastal belt, varying in width from 10 to 80 miles, the broadest stretch being from Luderitz Bay to Conception Bay. It is a barren wind-swept desert composed mainly of vast hills of yellowish sand, and lies west of the western portion of the Great Escarpment. The rainfall is extremely scanty and varies from 0 to 5 inches per annum.

Some five distinct zones of vegetation may be distinguished, viz.: that of the western slopes of the Escarpment, the Gravel Plains, the Sandy Dunes, the Rocky Hills, and the Seashore.

On the rocky slopes of the Escarpment the KokerBoom (*Aloe dichotoma*), *Euphorbia virosa*, and *E. dregeana* are most conspicuous, whilst along the foothills clumps of *Euphorbia brachiata* are common, and associated with them are plants of the Bushman's Candle (*Sarcocaulon Burmanni*) and *Pelargonium crassicaule*, *Augea capensis*, *Mesembrianthemum micranthum*, *Galenia africana*, and *Euphorbia namibensis*.

Below this the vast gravel plains are for miles and miles almost destitute of vegetation, or support a more or less scanty growth of Vogelstruis grass (*Eragrostis spinosa*). In some places the only plant on these plains is an annual *Mesembrianthemum*, on others nothing but a lichen growth covers the small pebbles. Towards the north only a few isolated plants of *Aerva desertorum* occur over vast stretches, while *Welwitschia mirabilis* is found in a few localities and is usually associated with *Zygophyllum Stapfii*.

The sand dunes support a very scanty vegetation, which is made up chiefly of isolated tufts of Vogelstruis grass (*Eragrostis spinosa*), *Eragrostis cyperoides*, the Ganna bush *Salsola Zeyheri*, *Statice scabra* and *Mesembrianthemum Marlothii*.

On the rocky hills fringing the seashore the vegetation is more varied, and is composed of many extremely interesting forms, such as *Mesembrianthemum opticum*, *Mesembrianthemum sarctanum*, *M. rhopalophyllum*, *Trichocaulon cactiforma*, and *Euphorbia lignosa*; other common plants are *Ectadium virgatum*, *Eremothamnus Marlothianus*, *Dicoma tomentosa*, *Pituranthus aphyllus*, *Augea capensis*, and *Lebeckia multiflora*.

On the seashore three plants are fairly common, viz.: *Salsola zeyheri*, *Chenolea diffusa* and *Salicornia natalensis*.

The river valleys which traverse the Namib carry a very typical vegetation. In the upper reaches of the valleys, especially in the north, considerable tree growth occurs, in the dry river beds the characteristic trees are the Anaboom (*Acacia albida*), the Camel Thorn (*Acacia giraffae*), the Omumborumbonga (*Combretum primigenum*), the Cape Ebony (*Euclea pseudebenus*), the Tamarisk (*Tamarix articulata*) and the Choris (*Salvadora persica*).

The low-lying valleys are practically dominated by vast stretches of nothing but the Aggennys Euphorbia (*E. gregaria*).

Nearer the coast, where several of the rivers disappear under the sand dunes, their underground courses can frequently be detected by the presence of the Naras (*Acanthosicyos horrida*) and the Tamarisk (*Tamarix articulata*) amongst the dunes. The Tamarisk has not received the attention which it deserves from an economic standpoint. It grows splendidly in the sand dunes and also in saline and alkaline soils, while it yields valuable timber and a plentiful supply of "galls" very rich in tannin; it also is very resistant to heat and drought. In North Africa the small fruits are much esteemed by the natives for medicinal purposes on account of the amount of turpentine which they contain.

In view of the facts set forth in this brief and all too sketchy and incomplete account of the veld, it is obvious that South Africa is first and foremost a pastoral country, and as such her stock-raising potentialities are mainly dependent on the veld. The greater portion of the natural grazing land throughout South Africa is subject to extremes of climate, periods of drought and harsh treatment at the hands of man, but in spite of all this its recuperative powers are untold.

The most outstanding and convincing of the facts which are brought to light by the preliminary survey of the veld is the need for its closer study, which should include amongst other things the careful mapping of the chief types of plants and their associated soils. One of the aims of the Botanical Survey of South Africa, recently established by the Government of the Union, will be the recording and mapping of these plants, while it is hoped that the mapping of soils will be undertaken by the long advocated Soil Survey. It is both pleasing and encouraging to note that provision has been made on the Estimates of Expenditure now before the House of Assembly for the salary of a Director of the Soil Survey.

If progress is to be made in the solution of the problems before us the closest co-operation must exist between the botanist and the chemist. For this purpose, permanent stations for veld research should be established in each of the different botanical regions, and this the Botanical Survey hopes, in the course of time, to do. In his preface to Memoir No. 1 of the Botanical Survey, the Secretary for Agriculture wisely remarks: "As time proceeds and as soon as the foundations are securely laid, it is hoped that whole-time officers will be appointed in the different areas, who will at first work under the direction of their more experienced colleagues, and will then later on become proficient and render valuable service on the Survey."

The Memoir referred to above has been the subject of a most favourable review in a recent number of the *Kew Bulletin*, in which the concluding paragraph is as follows: "The publication of so useful a memoir by the Government of the Union of South Africa affords welcome evidence of the enlightened view held by that Government of the value of science, and also indicates that they realise fully the need of acquiring an intimate knowledge of the resources of the country by the development and proper application of scientific method."

No one has demonstrated more clearly what can be accomplished by the co-operation of workers in different fields of research than Sir Arnold Theiler, the Director of Veterinary Research, with whom it has been my privilege to be associated in several of his investigations dealing with what he once termed "the unsolved stock diseases of South Africa." The cause of such diseases as Jacht-ziekte, Stijfziekte, Geeldikkop, Gouwziekte and Bovine Staggers was only discovered after a close study of the flora and veld conditions of the areas where these diseases occur. So convinced is Sir Arnold of the importance of the study of the veld in connection with obscure plant poisons that he has now specially attached to his staff a botanist whose whole time is devoted to this purpose.

If the veterinarian can make such progress with the aid of the botanist, there is no reason why similar results should not be attained by the botanist and chemist in the many problems of the veld that await them. To quote a specific case: it is well known that stock fatten more rapidly in the Vaal Kameel Doorn Veld in the winter than in any other part of South Africa, and that they may remain in good condition for a long time if removed from that region to another part of the country, but no one can explain the reason. The cause is probably to be found in some close connection between the warm sandy soil of this veld and the physiology of nutrition, but who can say, without the most careful enquiry? These problems can only be elucidated by the trained botanist working continuously on the spot, and working in co-operation with the chemist. The investigation of such questions is of enormous importance from an economic standpoint, and when such problems are scientifically and systematically attacked the veld will yield a hundredfold its present resources and its dangers will correspondingly decrease and diminish.

In conclusion, I wish to acknowledge my indebtedness to Miss Sydney Stent, of the Division of Botany, who supplied me with notes on the economic plants of the various regions of which she is making a special study.

Photo. by I. B. Pole Evans.

Fig. 1.—*Ipomœa Pes Capræ, Scævola lobelia, Osteospermum moniliferum, Strelitzia, augusta, Phœnix reclinata, Dimorphotheca fruticosa, Hibiscus tiliaceus, Carissa grandiflora, Mimusops caffra, Ptæroxylon utile, Millettia Sutherlandii.*—Port St. John's, Cape Province.

Photo. by I. B. Pole Evans.

Fig. 2.—*Cymbopogon nardus validus* in foreground, *Acacia* scrub on hill slopes, *Rauwolfia natalensis* lining stream below, forest on left composed of *Ptæroxlon utile, Millettia Sutherlandii, Harpephyllum caffrum, Ekebergia capensis, Cyclostemon argutus, Trichilia Dregeana.*—Port St. John's Cape Province.

COAST VELD.

Photo. by I. B. Pole Evans.

Fig. 3.—*Acacia pallens, Syzygium cordatum, Kigelia pinnata, Trichilia emetica, Ficus* spp.—Klasserie River Selati, Transvaal.

Photo. by I. B. Pole Evans.

Fig. 4.—*Acacia pailens, Acacia xanthophlœa, Diospyros mespiliformis, Sclerocarya caffra, Odina discolor, Acacia Benthami, Ricinus communis* in foreground.—Near Komati Poort, Transvaal.

LOW VELD.

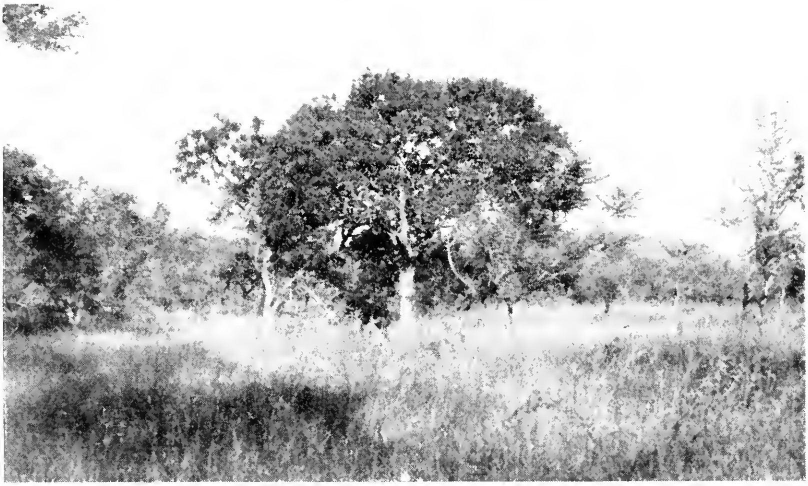


Photo. by I. B. Pole Evans.

Fig. 5.—Knoppiesdoorn (*Acacia pallens*), with the Van Wijk's Hout (*Bolusanthus speciosus*) on the left. Rooigras (*Themeda triandra*) in foreground.—Hectorspruit, Transvaal.

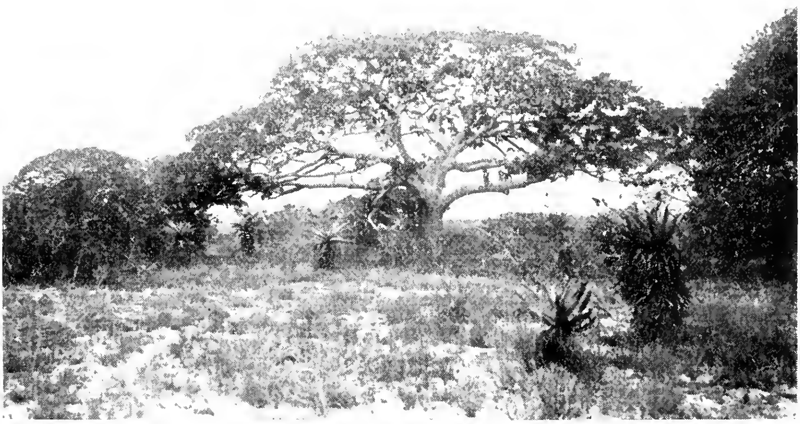


Photo. by I. B. Pole Evans.

Fig. 6.—Mahogany (*Afzelia quanzensis*), and *Aloe Marlothii*.—Xinavane, Portuguese East Africa.

LOW VELD.

Photo. by I. B. Pole Evans.

Fig. 7.—Beukenhout (*Faurea saligna*). Suiker bos (*Protea abyssinica*). Karee (*Rhus Gueinzii*). Rooi Gras (*Themeda triandra*) in foreground.—Near Zand River Poort, Transvaal.

Photo. by I. B. Pole Evans.

Fig. 8.—*Nymphaea stellata*, *Arundinella Ecklonii*, *Typha capensis*.—Zand River Poort, Transvaal.

WATERBERG SANDVELD

Photo. by I. B. Pole Evans.

Fig. 9.—*Themeda triandra, Andropogon ceresiaeformis.*—On the Drakensberg near Wakkerstroom.

Photo. by I. B. Pole Evans.

Fig. 10.—*Eragrostis plana* in foreground with *Acacia karroo, Protea Rouppelliae* on the hill slope, forest composed of *Podocarpus falcata, P. elongata, Ocotea bullata, Xymalos monospora, Celtis kraussiana, Olea laurifolia.*

EASTERN GRASSVELD.

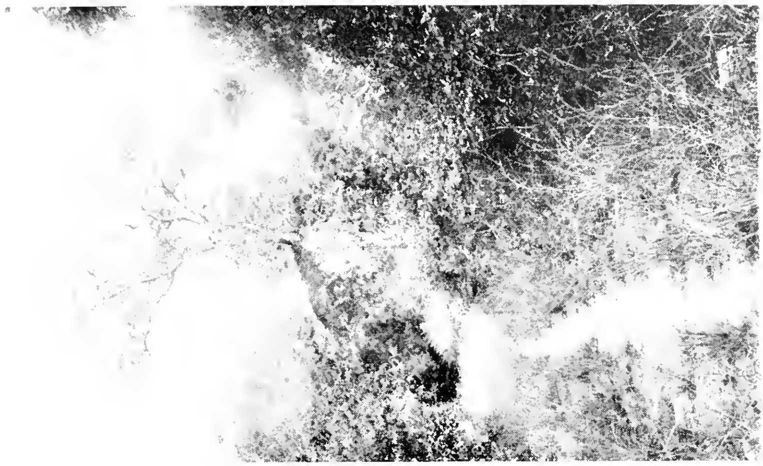


Photo. by I. B. Pole Evans.

Fig. 11.—*Podocarpus elongata* with *Olea laurifolia* behind.—In Pirie Forest.

EASTERN GRASSVELD.

Photo. by I. B. Pole Evans.

Fig. 12.—*Harpephyllum caffrum* with *Rhus laevigata* behind.—Pirie Forest.

EASTERN GRASSVELD.

Photo. by I. B. Pole Evans.

Fig. 13.—*Acacia caffra, Acacia spirocarpoides, Dichrostachys nutans, Olea verrucosa, Sclerocarya caffra, Acacia Burkei, Peltophorum africanum, Schotia transvaalensis, Boscia Rehmanni*, with *Kirkia Wilmsii* in foreground.—Near Chunie's Poort, Transvaal.

Photo. by I. B. Pole Evans.

Fig. 14.—*Euphorbia Cooperi, Croton Gubonga*.—Olifant's River, Transvaal.

BUSHVELD.

Photo. by I. B. Pole Evans.

Fig. 15.—Wilde Sering (*Burkea africana*), *Acacia karroo*, *A. robusta*, *A. spirocarpoides*, *Dichrostachys nutans*.—Springbok Flats, Transvaal.

Photo. by I. B. Pole Evans.

Fig. 16.—*Acacia spirocarpoides*, *A. Benthami*, *Themeda triandra*.—Springbok Flats, Transvaal.

BUSHVELD.

Photo. by I. B. Pole Evans.

Fig. 17.—*Acacia caffra, A. eriadenia, Cussonia paniculata, Zizyphus mucronata, Mundulea suberosa, Vangueria infausta, Rhus lancea, R. Gueinzii, Euclea undulata, Pavetta oborata, Dombeya densiflora, Aloe Marlothii.*—Waterval Boven, Transvaal.

Photo. by I. B. Pole Evans.

Fig. 18.—*Protea abyssinica, Combretum zeyheri, C. Gueinzii, Acacia caffra, A. karroo, Zizyphus mucronata, Euclea undulata, Pavetta oborata, R. Gueinzii, Euclea undulata, Pavetta oborata, Dombeya densiflora, Aloe Marlothii.*—Waterval Boven, Transvaal.

BANKEN VELD.

Photo. by I. B. Pole Evans.

Fig. 19.—*Themeda triandra* during March.—Kaalfontein, near Johannesburg, Transvaal.

Photo. by I. B. Pole Evans.

Fig. 20.—*Themeda triandra* in November.—Kaalfontein, near Johannesburg, Transvaal.

HIGHVELD.

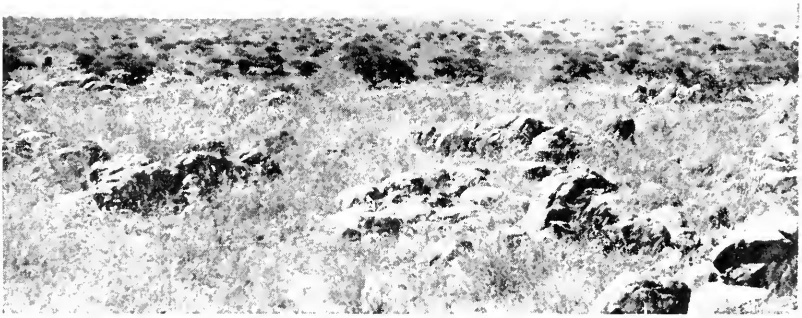


Photo. by I. B. Pole Evans.

Fig. 21.—*Acacia spirocarpoides*, *A. giraffa*.—Near Kimberley, Cape Province.

Photo. by I. B. Pole Evans.

Fig. 22.—*Acacia detinens*, *A. spirocarpoides*.—Near Windsorton Road, Cape Province.

GRIQUALAND WEST THORNVELD.

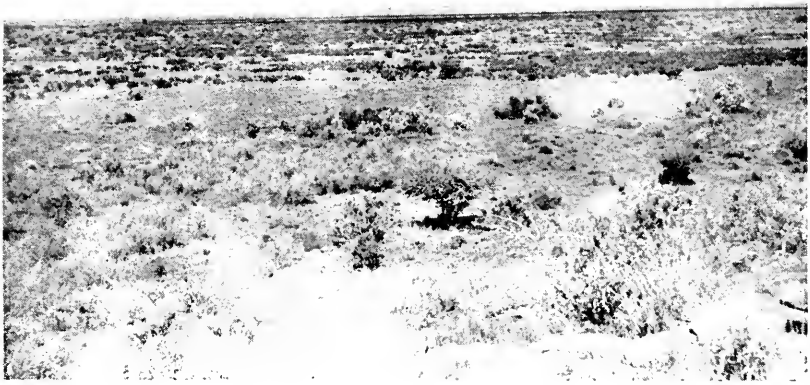


Photo. by I. B. Pole Evans.

Fig. 23.—*Acacia detinens*, *A. spirocarpoides*, *Tarchonanthus camphoratus*, *Rhigozum trichotomum*.—Near Douglas, Cape Province.

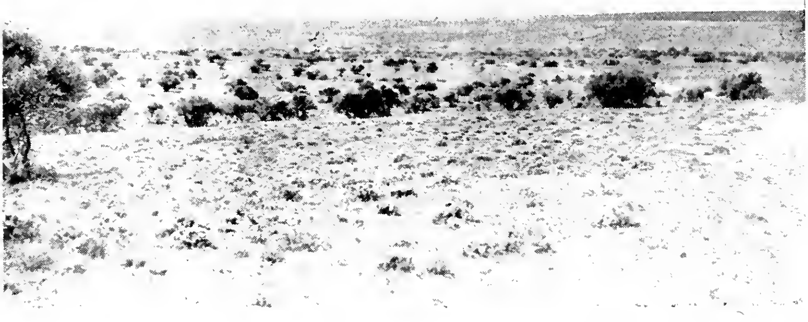


Photo by I. B. Pole Evans.

Fig. 24.—*Olea verrucosa*, *Rhus tridactyla*, *Pentzia incana*.—Near Postmasburg, Cape Province.

KAAP PLATEAU BUSHVELD.

Photo. by I. B. Pole Evans.

Fig. 25.—*Rhus viminalis, Olea verrucosa, Tarchonanthus camphoratus, Themeda triandra.*—Near Papkuil, Cape Province.

Photo. by I. B. Pole Evans.

Fig. 26.—*Acacia detinens, Olea verrucosa, Rhus tridactyla, Pentzia incana.*—Near Postmasburg, Cape Province.

KAAP PLATEAU BUSHVELD.

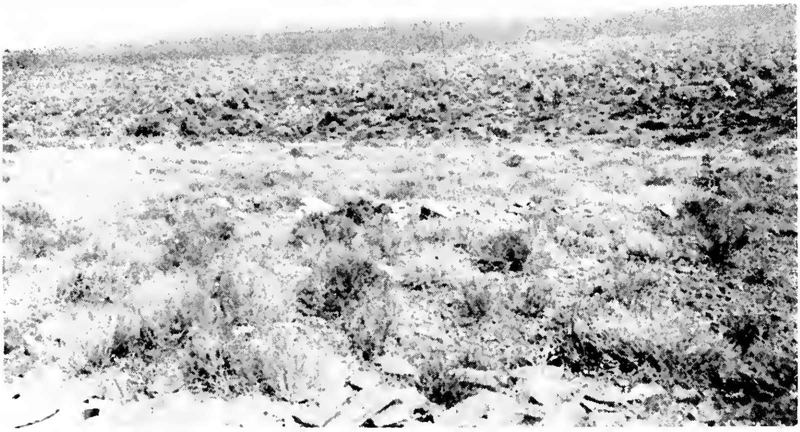


Photo. by I. B. Pole Evans.

Fig 27.—*Lebeckia macrantha, Pentzia incana.*—On Asbestos Mountains, Griquatown, Cape Province.

Photo. by I. B. Pole Evans.

Fig. 28.—*Tarchonanthus camphoratus, Pentzia incana.*—On Asbestos Mountains, Postmasburg, Cape Province.

VAAL KAMEELDOORN VELD OF ASBESTOS MOUNTAINS.

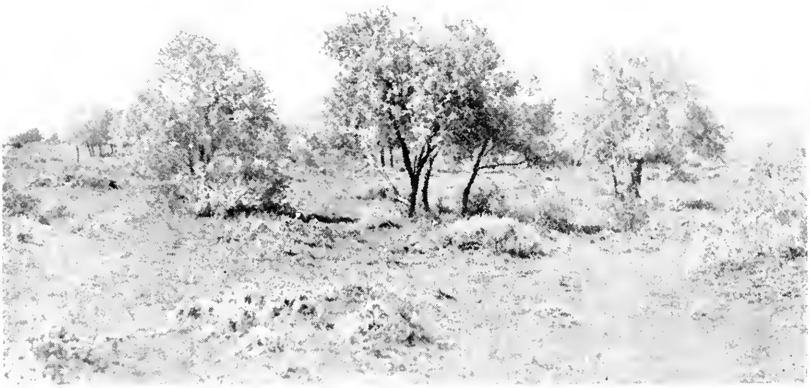


Photo. by I. B. Pole Evans.

Fig. 29.—Vaal Kameeldoorn (*Acacia hamatoxylon*) with *Pentzia incana* below.—Floradale, Cape Province.

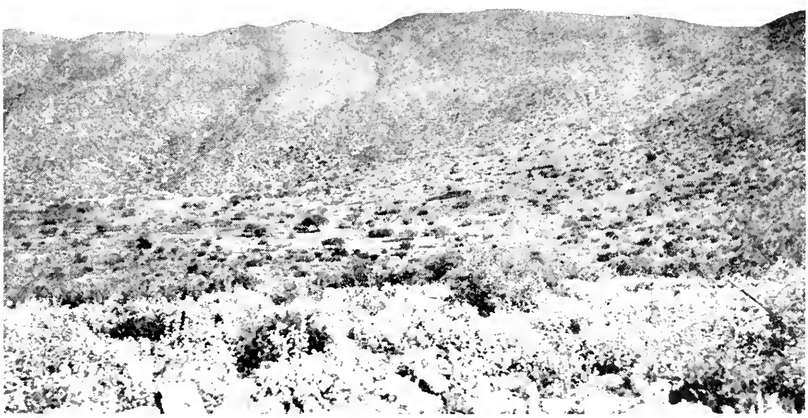


Photo. by I. B. Pole Evans.

Fig. 30.—*Croton gratissimum*, *Acacia giraffa*, *Boscia transvaalensis*.—Langeberg Range, Dunmurry, Cape Province.

VAAL KAMEELDOORN VELD OF ASBESTOS MOUNTAINS.

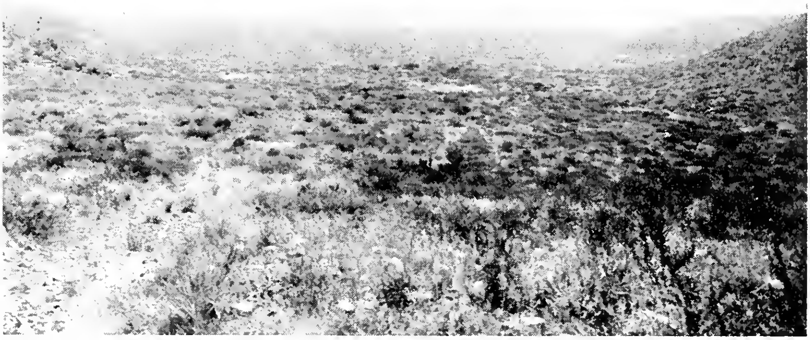


Photo. by I. B. Pole Evans.

Fig. 31.—*Acacia detinens*, *Croton gratissimum*, *Nymania capensis*, *Acacia giraffae*, *Boscia transvaalensis*.—Western slopes of the Langeberg Range, Dunmurry, Cape Province.

Photo. by I. B. Pole Evans.

Fig. 32.—*Salsola aphylla*.—Near Tsumis, South-West Africa.

KALAHARI SAND VELD.

Photo. by I. B. Pole Evans.

Fig. 33.—*Acacia detinens*, *A. Maras*, *A. heteracantha*, *A. dulcis*, *Combretum apiculatum*, *Dichrostachys nutans*, *Boscia Pechuellii* *Tarchonanthus camphoratus*, *Aloe rubro-lutea*, *Euclea undulata*.—Near Windhuk, South-West Africa.

Photo. by I. B. Pole Evans.

Fig. 34.—*Acacia heteracantha*, *A. dulcis*, *Combretum apiculatum*, *Aloe rubro-lutea*.—Near Windhuk, South-West Africa.

DAMARALAND THORN VELD.

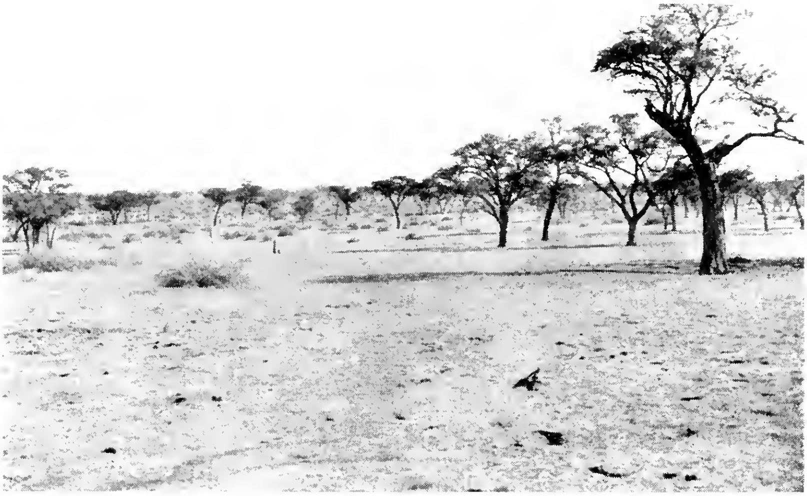


Photo. by I. B. Pole Evans.

Fig. 35.—*Acacia giraffae*, *Lycium* sp.—Heide, South-West Africa.

Photo. by I. B. Pole Evans.

Fig. 36.—*Acacia giraffae*, *Lycium* sp.—Heide, South-West Africa.

KAMEELDOORN VELD OF SOUTHERN DAMARALAND.

Photo. by I. B. Pole Evans.

Fig. 37.—*Restio* association.—Sir Lowry's Pass, Cape Province.

Photo. by I. B. Pole Evans.

Fig. 38.—*Helichrysum vestitum. Elytropappus rhinocerotis.*—Table Mountain, Cape Province.

CAPE VELD OR SOUTH-WESTERN VELD.

Photo. by I. B. Pole Evans.

Fig. 39.—*Euclea undulata, Pappea capensis, Schotia brachypetalia, Pteronia pallens.*—Touwsberg, Cape Province.

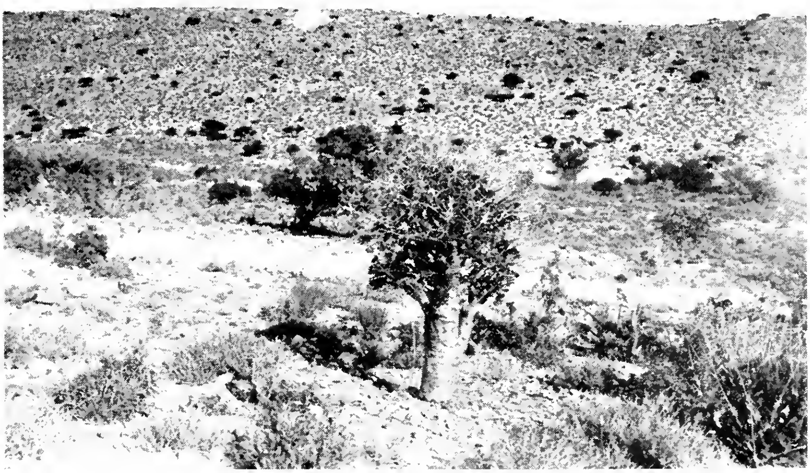


Photo. by I. B. Pole Evans.

Fig. 40.—*Cotyledon fascicularis, C. Wallichii, Euclea undulata.*—Near Laingsburg, Cape Province.

KARROO.

Photo. by I. B. Pole Evans.

Fig. 41.—*Euclea undulata, Pteronia pallens.*—Near Laingsburg, Cape Province.

Photo. by I. B. Pole Evans.

Fig. 42.—*Euclea undulata, Pteronia pallens Mesembrianthemum* spp.—Near Laingsburg, Cape Province.

KARROO.

Photo. by I. B. Pole Evans.

Fig. 43.—*Mesembrianthemum* spp., *Galenia africana*.—Near Sutherland, Cape Province.

Photo. by I. B. Pole Evans.

Fig. 44.—*Arthrosolen polycephalus*, *Enneapogon scoparius*, *Eragrostis truncata*, *E. obtusa*.—Near Luckhoff, Orange Free State.

UPPER KARROO.

Photo. by I. B. Pole Evans.

Fig. 45.—*Rhigozum trichotomum*.—Bushmanland.

Photo. by I. B. Pole Evans.

Fig. 46.—*Aloe dichotoma*.—South-West Africa.

KOKERBOOM VELD OF NAMAQUALAND AND BUSHMANLAND.

Photo by I. B. Pole Evans.

Fig. 47.—*Aloe dichotoma, Euphorbia virosa, E. gregaria, E. dichotoma.*—Between Holoog and Klein Karas, South-West Africa.

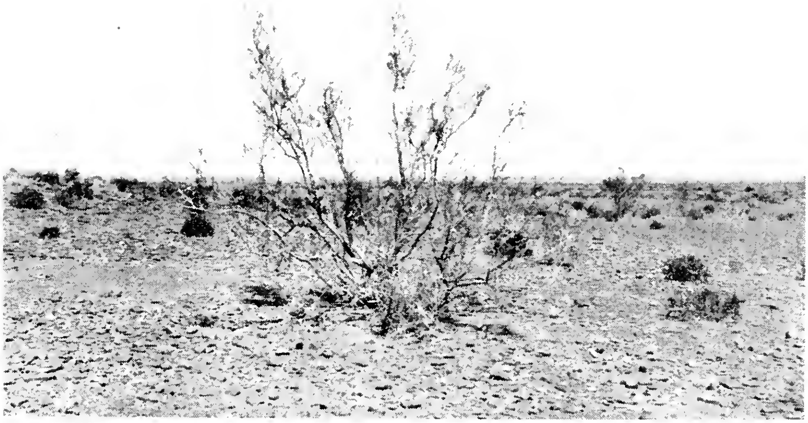


Photo. by I. B. Pole Evans.

Fig. 48.—*Parkinsonia africana, Zygophyllum* spp.

KOKERBOOM VELD OF NAMAQUALAND AND BUSHMANLAND.

Photo. by I. B. Pole Evans.

Fig. 49.—*Aristida dregeana*, *A. obtusa*, *A. subacaulis*.—Near Aus, South-West Africa.

Photo. by I. B. Pole Evans.

Fig. 50.—*Aristida brevifolia*.—Near Kuibis, South-West Africa.

KOKERBOOM VELD OF NAMAQUALAND AND BUSHMANLAND.

Photo. by I. B. Pole Evans.

Fig. 51.—*Euphorbia gregaria*.—Near Aukas, South-West Africa.

Photo. by I. B. Pole Evans

Fig. 52.—*Euphorbia gregaria*.—Near Aukas, South-West Africa.

THE NAMIB.

Photo. by I. B. Pole Evans.

Fig. 53.—*Eragrostis spinosa.*—Near Garub, South-West Africa.

Photo. by I. B. Pole Evans.

Fig. 54.—*Erva desertorum, Acacia stolonifera.*—Near Rossing, South-West Africa.

THE NAMIB.

Photo by I. B. Pole Evans

Fig. 55.—*Acanthosicyos horrida.*—Walfish Bay

Photo. by I. B. Pole Evans.

Fig. 56.—*Tamarix articulata.*—Walfish Bay.

THE NAMIB.

RECENT PROGRESS IN ASTRONOMY.

By H. E. Wood, M.Sc., F.R.A.S., F.R.Met.S.
Union Observatory, Johannesburg.

Presidential Address to Section A, delivered July 14, 1920.

I should like to commence my address by referring to the fact that the present year marks a definite epoch in the history of astronomy in South Africa. It is exactly one hundred years ago since the foundation of the Royal Observatory at the Cape of Good Hope. The Commissioners appointed by Act of Parliament "for more effectually discovering the longitude at sea" first discussed the question of the establishment of an Observatory at the Cape on February 3, 1820. There was then no permanent astronomical Observatory at the Cape, although the Abbé Lacaille had spent two years at Capetown (1751-1753) and had made a catalogue of southern stars. A bronze tablet erected by the South African Philosophical Society—now the Royal Society of South Africa—marks the site of Lacaille's Observatory in Strand Street.

On October 20, 1820, by an Order of His Supreme Majesty in Council, the Royal Observatory at the Cape was definitely established, and the first of His Majesty's Astronomers at the Cape—the Rev. Fearon Fallows—was appointed on October 26, 1820. There was considerable delay in erecting the necessary buildings, and it was not until the beginning of 1829 that the Royal Observatory was an accomplished fact. Since its inception the aim of this institution has been constant—to be the standard Observatory of the Southern Hemisphere, and to be for that hemisphere what Greenwich Observatory is for the Northern Hemisphere.

The state of South Africa one hundred years ago was very different from its state at the present time; equally so is there a very wide difference between the state of astronomy then and now. The distance of not a single star was known then, and it stands to the credit of the second of His Majesty's Astronomers at the Cape, Thomas Henderson, that he was the first to measure successfully the distance of a star—the star Alpha Centauri—although, partly on account of the remoteness of the Cape from Europe in those days, he was not the first to publish the distance of a star, being slightly anticipated by the European astronomers Bessel and Struve. At the present time the distances of many stars are known. It was the chief work of Sir David Gill to measure the distance of the Sun, which is the unit distance to which the distances of the stars are referred, and also to measure the distances of the brighter southern stars.

The great practical problem of astronomy is the measurement of the distance of the stars. A knowledge of stellar distances is required in all investigations into the structure

of the Universe. Early attempts to measure the distance of a star, although not successful in their actual object, led to far-reaching discoveries. Bradley, in 1725, in attempting to find the distance of the star Gamma Draconis, discovered aberration and nutation. Herschel discovered the existence of binary stars, and, on investigating the apparent changes in the positions of a few stars from those given in early star catalogues, discovered the motion of the Sun, and made a fortunate guess as to its direction of motion and velocity. His first determination depended upon the observations of only seven stars, but does not differ very widely from the results of recent investigations, in which the apparent motions of thousands of stars have been discussed. The application of the spectroscope has confirmed the result, and has added a direct determination of the solar velocity. Stars in a certain direction in the sky appeared to be moving towards the Sun; others in the antipodes of the sky appeared to be receding from us with the same velocity. This velocity has been determined to be 19·5 kilometres per second. It was soon realised that one result of the Sun's motion through space was to afford a new method of determining stellar distances applicable to distances so great that the ordinary direct method failed. In one year the Sun, and with it the whole of the solar system, moves through space over a distance equal to four times the distance between the Sun and the Earth, or 372 million miles. In ten years the distance moved is forty times the Sun's distance, and the distance increases directly with the time. Thus an indefinitely increasing base line is obtained, whereas in the direct method of determining a stellar parallax the base line cannot exceed 186 million miles, or two units. If, then, an exact comparison can be made between the relative positions of the stars at the present time and their relative positions many years ago, there must be certain differences due to the change in the point of view. The nearer stars lying in directions at right angles to the direction of the Sun's motion must be displaced with reference to more distant stars in the same direction, and generally the stars would appear to diverge from the apex of the Sun's way and to converge towards the solar antapex. If, now, the stars were all at rest, it would be a very simple matter to measure the distances of thousands and thousands of stars by their displacements relatively to more distant stars, and the number of stars whose distances could be measured and the accuracy of the results obtained would increase as the time increased. But analogy suggests that it is hardly likely that our Sun alone is in motion and all the rest of the stars are fixed in space, and investigation has proved that practically all the stars are in motion. If these motions were all at random, it would still be possible to determine the distances of groups of stars, for the random motions taken over the group would neutralise one another, and the group as a whole would be at rest. In this way Kapteijn, amongst others, has statistically determined the distances of various groups of stars. It had been suggested by Kobold, and later

became evident to Kapteijn in 1904, that the motions of the stars could not be considered to be entirely at random, and at the joint meeting of the British Association for the Advancement of Science and the South African Association for the Advancement of Science at Capetown in 1905, Kapteijn announced that there were two preferential directions of motion amongst the stars. This statement can be explained in a variety of ways. If the motions of the stars could be plotted on a three-dimensional diagram, with vectors representing the velocity and direction of motion of each star, the resultant surface would be an ellipsoid with one relatively long axis. This long axis of the ellipsoid would represent Kapteijn's preferential directions. More simply, it might be considered that there are two directly opposed streams of stars, which was the view taken by Kapteijn, who called the two streams Drift I and Drift II. Drift I is directed towards 90°, −12°, and Drift II towards 270°, −55°. These directions are affected by the motion of our point of observation—the Sun—and, if they are corrected for this, the directions are found to be 94°, +12°, and 274°, −12°, opposite to one another and in the plane of the Galaxy—which is a fact full of significance.

This discovery of systematic motions amongst the stars has greatly complicated the question of determining stellar parallaxes from proper motions, but has carried us much further in investigations into the structure of the Universe.

The investigation of systematic motions amongst the stars has occupied us at the Union Observatory for the past three years, and the portion of work we have undertaken is by no means completed yet. Ordinarily the process of determining proper motions is a very slow one. Meridian observations of star places are made at an Observatory and published as a star catalogue for a certain epoch. The work is repeated at the same or another Observatory at a later date and a catalogue published for a later epoch. By bringing the places of the stars to a common epoch, the difference between the two places for the same star, after all possible sources of error have been eliminated, is due to the proper motion of the star. This is a slow and tedious process, and it is never advisable to determine a small quantity as a difference between much greater quantities. Further, and this is very important, only those stars are dealt with which are bright enough to be observed with meridian instruments. The results would thus be incomplete, and only refer to the brighter stars.

It is a different matter when star photographs are dealt with. Suppose that two photographs have been taken with the same telescope of the same region of the sky, and with an interval of some years between them. These two photographs can be optically superposed and minutely compared with one another. If there were any motion common to all the stars of the region, this could not be detected, because the superposition of the two plates would automatically eliminate this. Such a common motion could be determined

only by reference to the meridian catalogue positions of whatever stars there were on the plates whose position had been determined by meridian telescopes at different epochs. The detailed investigation of the plates is carried on at the Union Observatory with the help of a stereo-comparator and blink-microscope. This is a wonderful instrument, which enables corresponding portions of the two plates to be compared in rapid succession, and shows at a glance relative displacements amongst the stars of a small region. The same result would be obtained, but with an enormous expense of time and labour, by measuring the co-ordinates of each star image on the two plates and comparing the measures for the corresponding stars. Discrepancies here would also show relative displacements amongst the stars on the plate. But whereas in this method every star must be measured to find the few showing motion, the blink-microscope selects just those few and practically ignores the rest, with the result that not only is the labour very much less, but also the liability of error. In actual practice, something like one in a hundred stars will show a small displacement with reference to its immediate surroundings. It remains to interpret actually what this displacement means. Theoretically, if the majority of the stars on the plate are at an infinite distance, so that it can be assumed that their relative configuration remains unaltered as seen from the extremities of a base line as long as that over which the Sun would move in twenty-five years, *i.e.*, 100 units (assuming twenty-five years to be the interval of time between the taking of the two photographs), then the displacement seen for any one star would indicate its shift against the infinitely distant background. This shift would be due to either or both of two causes—(1) the change of viewpoint, *i.e.*, the motion of the Sun, or (2) actual motion in a fairly near star. Thus from either point of view the blink-microscope would pick out the nearer members of the stellar universe.

A large number of plates taken with astrographic telescopes for the purposes of the Carte-du-Ciel has been examined at the Union Observatory with the blink-microscope. Mr. Innes has examined pairs of plates of the Greenwich, Melbourne and Sydney Zones, and, with myself, is examining the whole of the Cape Astrographic Zone. I have re-photographed practically the whole of the Cape Zone to secure new plates to compare with those taken originally. The time interval between the members of each pair of plates is about one-quarter of a century. The work of examining the plates is not yet completed, and there is the further great task of analysing the results to be done. Already it is evident from a preliminary survey of the portion of the work done that the moving stars so picked out by the blink-microscope divide themselves into two main classes. These are Kapteijn's Drifts I and II, and the directions of motions of these groups coincide fairly nearly with the directions predicted from the generally accepted positions of the apices of the drifts. Further, the division into two classes is so sharp and

pronounced as to suggest that we are not dealing with a distribution of stellar motions in one system such that the velocity surface is an ellipsoid with one relatively long axis, but that we are actually dealing with two definite streams of stars. The suggestion is made here tentatively, for further work has to be done, that the results obtained support the view that in the near vicinity of the Sun we have two star clusters intermingling and passing through one another. Further, the comparison between the blink-microscope motions for bright stars, bright enough to figure in meridian catalogues, with the catalogue results for the motion shows the hypothesis that the background of stars is at a relatively great distance to be fairly correct.

Much new work has been done recently in the determination of stellar parallaxes by indirect methods. These indirect methods all depend upon the simple principle that if you know the absolute magnitude of a star you can determine its distance from us from an observation of its apparent magnitude. If the lights of a town are seen from a distant elevated point, the more distant street lamps appear to be much fainter than the nearer ones, and, if it is known that the same type of street lamp is in use throughout the town, the distance of the far relatively to the near ones can be deduced from the apparent brightness of the two. If the distance of the near lamps is known, the actual distance of the more distant lamps can be calculated. Hence, if a number of stars of the same absolute magnitude can be recognised in the sky, the more distant ones will have a relatively greater (fainter) magnitude than the near ones. If the distance of the near ones has been determined by the direct method of determining stellar parallaxes, then the actual distances of the fainter and more distant ones can be deduced from the relation between the apparent magnitudes.

There are various ways in which the absolute magnitude of a star can be estimated. Adams and Kohlschutter, in 1917, detected differences in the relative intensity of certain lines in stellar spectra depending upon the absolute magnitude of the star. Consequently, by comparing spectra of stars of the same type they can deduce the absolute magnitude of the star, and then from its apparent magnitude its distance. This is a wonderful extension of the work of the spectroscope, which was used primarily to find the chemical constitution of a star, then its velocity, and now its distance.

There is a certain class of stars designated the helium stars. There are many reasons for considering that such stars are at the zenith of stellar evolution and are the hottest stars. They are the most massive of the stars, and, further, they all have approximately the same mass. Hence, if a star is found by the spectroscope to be a helium star, its distance can at once be deduced from its apparent brightness. Thus the only limit to determining the distance of a helium star is that imposed by the spectroscope—there must be enough light to show the character of its spectrum.

By investigating all the known scattered helium stars, Charlier finds that they form a bun-shaped cluster having dimensions of the order of 6,000 light years by 2,000 light years, and that our Sun is about 500 light years away from the centre of this system. Helium stars are also shown by the spectroscope to have very small velocities or to be nearly stationary in space, so that when a displacement is found for a helium star, this must be chiefly the reflex of the solar motion, and so the distance of the star can be deduced from this displacement.

It has been found possible with modern instruments of exceedingly powerful light grasp to detect the presence of helium stars in globular clusters. This enables the distance and dimensions of the cluster to be at once deduced, on the assumption that all helium stars are of the same order of absolute magnitude. The conclusion is arrived at that such a cluster as the Hercules cluster is no less than 100,000 light years away, and is really a stellar system almost approaching in dimensions to those attributed to the Milky Way. These tremendous figures must be accepted with reserve until it has been conclusively proved that the stars of these compact clusters differ in no respects from non-cluster stars. The chief use of such powerful instruments as the new 100-inch reflector of the Mount Wilson Observatory will be to investigate the spectra of the stars in such clusters, with a view to increasing our knowledge of these very distant systems.

Much has been learnt from the study of the behaviour of variable stars. One particular class of variable star—the Cepheid variable—has recently attracted much attention. It is now considered by many astronomers that the Cepheid variable—in which the rise to greatest light is fairly rapid and the fall more leisurely—is due to the pulsations of a gaseous star obeying the laws of a perfect gas. From this it has been deduced that the period of vibration of the mass of gas varies directly as the density, and hence upon the absolute magnitude of the star. Many such variables have been found in the smaller Magellanic Cloud, and have led to an estimate of the distance of this system, viz., 60,000 light years. The law connecting the period of variation with the absolute magnitude has been tested for all known Cepheid variables, and has been found to be consistently true. Hence the determination of the distance of a Cepheid variable is a simple deduction from its period of variation and its apparent mean magnitude.

One fruitful result of the spectroscopic examination of stars, combined with an investigation into their absolute magnitudes, has led to the discovery of two types of stars—the giants and the dwarfs—and has considerably modified our ideas as to the order of stellar evolution. Briefly, the stars can be divided into six principal spectral classes (omitting some minor classes), viz., helium stars, hydrogen stars, calcium stars, solar stars, and stars with fluted spectra. These are referred to as B-, A-, F-, G-, K- and M-type stars,

and the order of evolution was supposed to be in the direction from the B-type stars to the M-type stars, although Sir Norman Lockyer always maintained that there must be stars of ascending temperature as well as stars of descending temperature. The discovery of giant and dwarf stars supports Sir Norman Lockyer's view, and gives us more explicit ideas of stellar evolution. A large mass of gas in an extremely diffuse state may be a giant M, or red, star. Obeying the laws of a perfect gas, it will shrink or increase in density and rise in temperature, passing through the spectral classes K, G, F, A to the helium stage B when it has its maximum temperature. Throughout this part of its history its absolute magnitude remains the same, its diminishing surface area balancing the increased emissivity due to higher temperatures. At the helium stage the star's density has become so great that the perfect gas law is no longer obeyed. The loss of heat by radiation is now greater than that generated within the star, which now commences to fall in temperature. The star now passes down the spectral scale in the order A, F, G, K, and becomes once more a M-type star, but now its density is great, *i.e.*, it is a dwarf star. Thus, when the M-type stars are classified according to absolute magnitude, they fall into two distinct groups, with a considerable difference of absolute magnitude between them. There will be similar groups for the K, G, F and A classes, with decreasing differences of magnitude between the classes, but there will be only one class of B-type star. Not all stars can reach the helium class—they are not sufficiently large enough to develop the necessary high temperature. Our Sun, comparatively a small star, is thought not to have risen above the F-, or calcium-, type. The helium stars are considered to be the largest of all stars, and to be probably all of, roughly, the same size, of the order of about one thousand times the Sun's mass. Professor Eddington has recently studied the condition of stellar existence as a consequence of the laws of perfect gases, and concludes that there is a definite limit to the mass of a star, beyond which it could not exist as an entity. This limit is probably represented by the helium-type stars.

There is an important relationship between spectral-type and stellar radial velocity, the significance of which is not yet thoroughly understood. Each spectral class has a certain velocity, which diminishes from the M-type to the B-type, the slowly-moving helium stars. By some it is considered that this represents equipartition of energy amongst the stars, *i.e.*, for all the stars the product of the mass and the square of the velocity is constant, so that the massive B stars have low velocity and the less massive M-stars greater velocities. Considering the comparative emptiness of space and the enormous distances between stars, it is very difficult to see how equipartition of energy has come about. Such a view would compare the distribution of stars in the Universe and their movements with the motions of molecules in a gas.

The enormous distances deduced for the globular clusters is very much exceeded by those found for the spiral nebulæ by these indirect methods. The spectroscope has shown that the spiral nebulæ have radial velocities very much greater than those of the stars. This fact, combined with the absence of any detectable cross or proper motion indicates their distance to be very much greater than the stars. The discovery of novæ or new stars within certain of these nebulæ confirms this idea, and has led to estimates of their distance. The theory is, that whatever celestial catastrophe it is which gives rise to the outburst of a new star, the order of magnitude is the same, whether the occurrence takes place within a spiral nebula or within our own Milky Way. Hence, from the apparent brightness of the new star in the nebula, its distance can be estimated in terms of the distance of the Milky Way.

Such ideas as these concerning the existence of huge stellar systems at inconceivably great distances, or "island universes," are only tentatively accepted by astronomers. They represent logical deductions from observed facts, but the facts are still very meagre. Also, they involve extrapolations from physical laws based upon experience of the behaviour of matter under the conditions existing on this Earth, and the curve of our experience may in its remoter branches take some unforeseen direction. For instance, certain facts connected with the Great Nebula in Orion can only be explained by supposing that the mass of gas which constitutes the nebula must have a density less than one-millionth of that of ordinary air at sea-level, and yet in some way or other this gas is incandescent. It must be admitted that our knowledge of matter in this state is very meagre.

Thus these ideas can only be accepted with caution until the convergence of different lines of research approaching from different directions and the steady accumulation of unassailable facts puts them on a firmer foundation. If they are wrong, they will fall to the ground, but even a false hypothesis has served a useful purpose in indicating methods of research. In this region of astronomy the astronomer waits somewhat upon the physicist and chemist to inform him of the behaviour of matter under very varied conditions of pressure and temperature.

GEOLOGY IN RELATION TO MINING.

By F. P. Mennell, F.G.S., M.I.M.M.

Presidential Address to Section B, delivered July 15, 1920.

The original occupation of most of South Africa, Rhodesia excepted, has been due to the pioneer efforts of the farmer, or, more correctly, the pastoralist, rather than the miner. It cannot, however, be gainsaid that there is no country which owes its material advancement in greater degree to its mining industry. It is difficult to picture what South Africa would be like without its gold and diamond mines and the cities which their wealth has called into being. There may, of course, be some controversy as to whether pastoral simplicity would not have resulted in more ideal conditions from the point of view of those economists who follow Ruskin in declining to regard the income alike of the country and of the individual as the best test of real progress.

We are not, however, concerned to-day, except indirectly, with the economic or sociological aspects of this question. We have met together as students of physical science, and we have to consider the application of the science that we profess to the problems which confront us, which have arisen through conditions that must be reckoned with whether or no they have our concurrence or our approval.

Personally, though I missed the first pioneer activity—the most interesting period of all—it has been my privilege to follow all the later developments of the country in whose chief town we are holding our Annual Congress. At the time of my arrival I do not think a single dividend had been declared by a Rhodesian company, so that I have seen most of the work of placing the mining industry on a sound basis. In some of the developments which have taken place I have had an actual share, and in all of them I have taken a close interest, quite apart from the merely material considerations involved. My province has, in fact, been that of the geologist rather than the mining engineer, and it is from the geological standpoint that I intend to discuss some of the problems which confront, not only this country, but South Africa as a whole at the present day.

All thoughtful people will, I think, admit that we are in the throes of a great industrial revolution. I do not refer to the position of labour, but to the larger problems of industrial readjustment which now confront all civilised nations. The conception of England as the workshop of the world, on which Cobden largely based his successful Free Trade campaign, can now be seen in its true perspective as constituting a mere passing phase. The great war has undoubtedly done

much to help on the realisation of this fact, but, even without the war, its recognition was none the less inevitable, in spite of the obstinate refusal of a large school of English economists to face the situation. At the time when the Corn Laws were repealed, England was believed to possess unassailable supremacy in her iron and steel industry, so much so as to be able to base other industries, such as the production of cotton and woollen goods, upon that supremacy, combined with her unrivalled position as a producer of coal. Yet it is already thirty years since the United States wrested from Britain the premier position in the iron industry. To-day the American production is three times that of the Home Country, and Germany, which passed ahead of Great Britain in 1903, had even before the war increased the yield of its furnaces to nearly double that of the British ironworks. We have recently witnessed the successful establishment of blast furnaces in Canada, in Australia, in India, and still more recently in South Africa itself, where three separate concerns are now in operation. It is easy to see that the day cannot be far distant when the Empire will be self-supporting in the iron and steel industry, except as regards certain special departments, wherein the inherited skill and hard-won experience of the British ironmaster and his workmen will enable them to maintain their position for another generation at least.

Our modern civilisation, it has been claimed, has as its basis the successful utilisation of mineral products, and especially of metals. I have cited the iron industry partly for this reason, and partly because it was for so long regarded as peculiarly British. It is clear, too, that if the newer nations of the Empire become independent in that direction, they will easily develop in others. It must also be remembered that what has been said of Britain is applicable in large measure to the rest of Europe. Some twelve years ago I pointed out in my book, "The Miners' Guide," how imperfect was the adjustment of the mining industry to modern conditions. The centres of production often had then, and still have in great degree, no relation whatever to the principal sources of supply of several important metals. The aluminium ores of France even now go across to America for treatment, and those of British Guiana are going to Canada, while the manganese ores of India also go half-way round the world for treatment. The same applies to the asbestos and chromite in which this country is so rich, and to other products, like corundum, which is largely supplied by the Transvaal. The enormous copper deposits of the Congo are still only scratched, and the rich zinc ores of Northern Rhodesia are only just being investigated, while absurdly low-grade deposits of both these metals are being actively worked in Germany and elsewhere. The war has drawn attention in the most forcible way to some of these anomalies, and there can be no doubt that the Old World centres of civilisation will have to face the passing of their supremacy in the metallurgical industries to newer lands with larger areas and proportionately greater

natural resources. It is inevitable in the long run that those places with the largest deposits of each particular mineral will develop into the greatest centres of production, unless they are wholly deficient in fuel or other sources of energy.

If this country has the great future before it which most of us believe it has, we must show that its internal resources are sufficient in kind and in amount to form the basis of those industries which are necessary to make it to a great extent independent of importation from overseas. Here the aid of the economic geologist is of the utmost value. Personally, I believe that the Union of South Africa can obtain from within its borders supplies of almost everything that is essential for its industrial development, and the same may be said with equal confidence of Rhodesia. Though the latter cannot claim to rival the gold returns of the Rand, it possesses an almost unequalled variety of mineral products, actual or potential. Already it leads the world in its output of chromite and of the higher grades of asbestos, and the time cannot be far distant when its enormous resources in coal, zinc, iron and copper ores will be exploited as their output justifies. These will, no doubt, have their development assisted by the employment of one or other of the great sources of water power which exist at various points in the territory.

We must not, however, be led away into the tempting pursuit of patting ourselves on the back, so to speak. It is my intention rather to show what practical steps can be taken to foster the development of the great supplies of the various mineral products which we believe exist. In this connection I shall confine myself chiefly to a consideration of the channels into which the activities of the mining geologist can be directed, and inquire in what way his services may be utilised to most advantage.

It may at once be said that a considerable part of the foundation has already been laid, though it is not altogether complete, and requires a number of gaps to be filled before it can be utilised as a base for the superstructure we hope to build. Nevertheless, during a period lacking the excitement of sensational new discoveries, the descriptive side of the subject has made good progress, and we now have as a result a fair knowledge of the mode of occurrence of a large number of the more important mineral deposits in the country. At the same time, a good deal still remains to be learnt, more especially with regard to certain of the base metals on which our future industrial progress so largely depends, and it is to be hoped that contributions to this branch of the subject will not be less numerous in the future. Mining engineers can do much to help on this department of geological work. Points of great value can often be gathered from their reports, and these would be still more useful if the writers would make a practice of having their rocks named by competent authorities. It is very misleading to have a rock referred to as a "quartzite," for instance, when a petrologist could at once have pointed out that it was of igneous origin, and the reports of the Geological Surveys might be utilised to

give a general idea of the geology much more frequently than is the case. Another point to which reference may be made is the necessity of discrimination between various types of association in dealing with the relations between ore-bodies and rocks. This concerns the mining geologist as much as the engineer, who does not profess to be a geological expert. Thus, there is a world of difference between the occurrence of an ore-body *in* a rock and the mere presence in the vicinity of some rock *assumed* to have a genetic connection with the deposition of the ore.

This leads me into what is more especially the province of the mining geologist. In discussing the origin of ore-bodies, it is clear that there are two perfectly distinct types of genetic association. These are well illustrated by the ores which are usually found in close association with acid and basic igneous rocks respectively. There are, it is true, a number of very important metals—gold, silver, copper, lead, zinc, antimony, etc.—which appear to have no very well-marked tendency, except over limited areas, to occur in connection with one particular rock type rather than with others. But with other minerals the case is different. There are, in fact, two very well-defined groups of minerals, one of which occurs almost exclusively in conjunction with basic rocks like serpentine, while the other is almost invariably associated with acid rocks like granite and its offshoots. The basic group includes the metals platinum, chromium, manganese, nickel and cobalt, as well as magnesite, talc, asbestos, and also the diamond. The acid group comprises such metals as tin, tungsten, bismuth, molybdenum, uranium, tantalum, zirconium, cerium and thorium, together with minerals like mica and, perhaps, graphite. Now, a little consideration will show that some of the leading members of these two groups differ radically in the manner of their association with the rocks which appear to control their occurrence. The minerals of the basic group are almost invariably found inside the limits of the rock mass with which we associate them. Platinum and chromite, for example, are found in such rocks as serpentine and its allies, and these rocks form both the matrix, or lodestuff, and the country of the deposit. With some of the minerals of the acid group the case is quite different. Tin and tungsten, for instance, and notably the richest and most persistent deposits of those metals, do not occur as a rule in a granite matrix, or even with granite as their country rock. They generally favour a quartz-ore matrix, which seems to be connected with granitic intrusions, as shown by the invariable presence of granite in the near vicinity, but they frequently have sedimentary or metamorphic rocks forming the walls of the lode. This obviously indicates a difference in the nature of their genetic connection with the associated rock types, but, as a discussion of the matter is likely to lead us into regions where controversy is still acute, I do not propose to go further into it here.

At this point it seems desirable to emphasise the necessity of caution in applying current theoretical conceptions to particular occurrences which may be encountered, for theories which are widely held to-day may become discredited within a surprisingly short time as knowledge advances. As an instance of how detailed investigation of the facts may alter the views held as to the genesis of certain ore deposits, I may cite the case of some of our Rhodesian gold reefs. The theory that I myself formed, after making a preliminary examination of several mining districts, was that they were intimately connected with the intrusion of the great granite masses which are so prominent a feature of Rhodesian geology, though I pointed out that there were some which appeared to be of earlier and some of later date. Several years after, Mr. Maufe drew attention to the close association of many reefs with finer grained acid intrusive rocks, though he did not clearly indicate whether they were all of one age. It is quite probable that I had not allowed enough weight to the influence of the smaller intrusions, some of which certainly show every evidence of being genetically connected with the deposition of gold ores. That it does not do, however, to dogmatise too freely on apparent associations is well illustrated by what is now known of the Sebakwe district. The reefs there include those of the largest gold producer in the country, namely, the Globe and Phœnix, as well as the Gaika, Moss, and other smaller properties. These are all situated along the margin of the granite, and might well be claimed as typical examples of the theory of close association with the intrusion of that rock. Closer examination, however, shows that the reefs cut across certain dykes of the granophyre family, which may be termed felsites, or quartz-porphyries. The latter are clearly younger than the granite, and it might, therefore, seem that the deposits belong to the group of which the importance has been emphasised by Mr. Maufe. The fierce light of publicity which shone upon the Globe and Phœnix Mine during the great lawsuit over the right to work under the John Bull claims has nevertheless had as one result the demonstration that there are still younger igneous rocks which have to be taken into account. These are a series of dykes ranging in composition between dolorite and porphyrite, and usually much altered with production of carbonates, though not affected by the more intense agencies of metamorphism. These were first noticed at the Gaika Mine, and later on in the Rennie-Tailyour Concession, and I had been puzzled by the fact that they occasionally carried gold. The observations at the Globe and Phœnix showed that they cut both granite and quartz porphyries, but were nevertheless intersected by the reefs in that mine. We thus see how more and more detailed knowledge may gradually alter our opinions regarding the genesis of particular ore deposits, though each one appeared in turn to fit in admirably with the facts as far as they were established at the time. It may be noted that association with the basic dykes seems clearly indicated in this instance as the final

solution of the problem, since there is a single intrusion, entirely similar in every way to the others, which cuts through the reefs near the seventeenth level, thus assigning their formation to the period during which the dykes were being intruded.

What is really of most value in discussing ore deposits is unquestionably detailed field work, influenced as little as possible by theoretical considerations. As an example may be cited the close examination of the Witwatersrand goldfield carried out by Dr. Mellor. It is true that Dr. Mellor has made certain theoretical deductions from his observations which I have publicly dissented from. It is for this very reason, and also on account of the attacks recently made upon the official interpretation of the Rand's geological structure, that I specially desire to emphasise the importance of such a detailed scrutiny of these great gold deposits. We may not be at all inclined to agree with the conception of the Rand gold as being of alluvial origin, but there can be no two opinions on the part of any unbiased observer regarding the value of the field work itself. It may not be out of place to add that people would do well to think twice before accepting the ideas of a school who do not object to be described as "unorthodox geologists." In particular, attention may be drawn to the absolutely unequivocal declaration recently made by Dr. Rogers that the reefs of the East Rand can be followed without any break right through the point where a fault is postulated by the unorthodox, which is absolutely necessary to substantiate certain of the hypotheses which they have advanced.

I do not at all suggest that it is desirable to fetter the mining geologist in any way. By all means let him theorise. Nevertheless, it cannot be gainsaid that his theories are worse than useless if they cause him to overlook any important fact. To be perfectly frank, I am strongly of opinion that the chief function of the mining geologist lies in the correct interpretation of structural features. Thus, in the study of ore deposition, the nature of the fractures that have determined the position of the ore-body is of the first importance, if it is related to fracturing, or, on the other hand, the fact that a particular occurrence has not been so determined is equally important. Another problem which it is necessary to solve is the relation, if any, which exists between the ore-body, or the richer portions thereof, to adjacent rocks or rock structures. This may involve a nice discrimination between the essential and the accidental features in the associations of the deposit, and although such associations have been correctly diagnosed in certain cases—for instance, that of the well-known "indicators" of the Ballarat goldfield in Australia—without geological assistance, it is probable that close study by trained observers would lead to the recognition of many similar but less obvious examples elsewhere. Even more important may be what is perhaps to be regarded as applied mineralogy, namely, the investigation of the extent to which secondary processes have influenced values in the

upper part of an ore-body, and hence the probabilities of the downward extension of the valuable mineral. This is clearly by far the most important matter in estimating the possibilities of newly-discovered lodes or mineral districts, and one to which far too little attention has been paid in the past, both in technical literature and in mining education. Newly-opened properties are frequently reported on by men who may be experienced in running mines, but have little or no conception of the influence of surface enrichment processes. Yet comparatively undeveloped deposits require for a reasonably correct appraisement of their possibilities an examination made with every assistance that the scientific study of ore-bodies can afford. Their investigation comes, in fact, within the province of the mining geologist rather than that of the mining engineer. At the same time, the raw geologist may be as dangerous a guide in certain cases as the so-called "practical man," because it is absolutely necessary in solving the problems presented by mineral lodes to have due regard to those severely practical considerations which may be summed up under the head of working facilities.

There are, of course, instances in which secondary enrichment processes may render a lode workable to a considerable depth, even when the primary ore is altogether unprofitable. In the case of such metals as iron, the masses of ore produced in the course of surface enrichment are often so large that they constitute by far the most considerable of the deposits which are commercially exploited. Then, too, in dealing with metals like copper, zinc and lead, the possibility of impoverishment of the outcrops, or even the removal by leaching of much of the metal-bearing mineral at various other points, especially in the neighbourhood of water-level, must be borne in mind. An iron-bearing gossan may be all that represents a rich copper lode on the surface. We have also to consider what may be termed "mixed deposits," such as copper-tin lodes or lead-zinc lodes, in which one metal tends to replace the other in depth. Thus many of the Cornish tin mines began their career as producers of copper, while the great Broken Hill lode in Australia, and that of the same name in Northern Rhodesia, commenced as producers of lead, but are turning into zinc mines as they are followed downward. The problems presented by such deposits are of great complexity, and experience alone can teach the observer how to avoid the many pitfalls which beset his path.

Turning to another side of the science of ore deposits, we come to the elucidation of the blanks and breaks which may occur in the distribution of the valuable minerals through a lode. In many lodes a particular section is often much the richest, and may alone be profitable—for instance, the footwall may be very rich and the rest so poor as scarcely to be worth mining. Still more frequently the valuable portions form distinct patches, which may be sufficiently well defined to constitute what are commonly known as shoots of ore. Then, again, we may have another kind of discontinuity, due to the action of such geological processes as

faulting, or the intrusion of igneous rock subsequent to the deposition of the ore, which may result in all kinds of disturbances and displacements. These constitute a very important branch of the study of ore deposits, and are one of the most frequent occasions for geological assistance to be called in by those responsible for the conduct of mining operations. In all cases of discontinuity, whether due to faults or intrusions, or merely the result of the circumstances under which the ore was originally deposited, the important point to decide is whether there is a chance of picking up the ore-body again or not. The mining geologist must find out whether the displacement is large or small in amount and indicate its direction, or, if there is no displacement to account for the pinching out of the lode, he must give an opinion as to whether the association of the pay-ore with particular geological features is such as to warrant the expectation of encountering fresh shoots along the strike or in depth. There are even cases where perfectly distinct ore-bodies may be presumed to recur regularly in conjunction with special structures—a well-known example of this is provided by the "saddle reefs" of Bendigo, in Australia.

I have no desire to labour these points on the present occasion, nor do I propose to deal with such strictly geological problems in connection with mining as the location of concealed coal seams or oil pools. It will be sufficient to point out that the kind of work required in the investigation of the mineral resources of a country is far more closely allied with that necessary to lead to success in drilling for oil than is generally realised, although in South Africa it is more obvious than in many other countries. For instance, the definite location of the Rand "Main Reef" series in the most remote district would clearly justify the expenditure of capital to open it up on some scale. The mere identification of a particular rock as similar in every respect to another already known as an ore-carrier is, in fact, a most useful piece of information, and should lead to close examination of its outcrop. Then, again, the determination of the various periods of ore deposition may be of great assistance to those in search of valuable minerals, even if only by warning the prospector not to waste his time on rocks laid down or intruded, as the case may be, subsequent to the last period of mineralisation. These periods may, of course, differ for different metals—a fact which must be clearly borne in mind. It will be seen that theory does not enter at all into most of these questions, or only in very small degree. For instance, we should bore for the Main Reef just the same, whether we considered its gold as alluvial, following Gregory, Mellor and others, or as of magmatic origin in the way that Horwood contends.

In conclusion, I may briefly refer to the fact that industrial progress is in some degree directly bound up with the conduct of mining operations. The modern tendency is undoubtedly more and more for the mine to become other than a mere producer of raw material. In America especially

one sees such readily saleable products as sheets, rods, pipes, wire, alloys, metallic pigments, etc., being put on the market rather than concentrates, matte, or unrefined metal. Not only is this the case, but there is another important side to the question. The economical treatment of many ores demands cheap supplies of certain chemicals. Thus the extraction of zinc or copper may often be best effected by leaching with sulphuric acid. In localities far from the present centres of production this involves undertaking the manufacture on the spot, and it need hardly be said that this is a big step towards further industrial developments. Such instances could readily be multiplied, but it suffices for my present purpose to point out that under existing conditions we can enter upon these commercial undertakings without fear of being undersold by Europe or America—a sure indication of the progress which is bound to follow in the near future from the utilisation of our abundant natural wealth under intelligent technical direction.

CAUSES LEADING TOWARD PROGRESSIVE EVOLUTION OF THE FLORA OF SOUTH AFRICA.

By T. R. Sim, D.Sc., F.L.S.

Presidential Address to Section C, delivered July 16, 1920.

Wherever one travels in South Africa changes are seen to be going on in the vegetation and in the nature of the veld, and the longer one lives in South Africa and observes what is happening, the more evident does it become to him that the actions of civilised man are usually either directly or indirectly connected with these changes, and that these actions are often self-centred and exigent to a degree which is not permanently beneficial to the community, and which tends toward further and more serious changes in the future, on which the life of South Africa as a habitable region depends.

I refer not only to changes in the local floras, but also to resultant changes in the climate as a whole, influenced, if not brought about, by these flora changes. I am led to take this subject because with time and travel I see more definitely the course and cause of changes constantly taking place under our eyes upon everything which comes under our cognisance—changes usually regarded as natural changes, which, on account of their insidious nature, often pass unnoticed, or, if noticed, are considered either trivial and not worth attention, or else unsurmountable and so beyond our powers, neither of which opinions are exactly correct.

These changes include the evolution of the flora of South Africa as it is going on now—the evolution of the flora as a whole, and of parts of it—of regions, districts and areas; the reflex action of that changed flora on the climate, and again of changed climate on the flora—evolution which, though insidious, can be seen and recognised during a lifetime, even without written records, and all bearing a trend which is unmistakable. That trend is not necessarily the evolution of new species, but rather the gradual disappearance of what were climax types and the substitution of species of a more xerophytic nature.

Man and his actions play an important part in producing this change, for not only does he bring with him the weeds and survivors of cultivation, but through cultivation he destroys the natural herbage, and gives these aliens opportunity for naturalisation, of which some of them have freely availed themselves, sometimes to the exclusion of native species.

Cultivation is, however, a necessity, and its attendant troubles are more or less inevitable. We have nothing to say against good cultivation in which the original flora is displaced by cultures yielding permanently returns of more value than the original, without having other detrimental effect.

But it is rather with pastoral agriculture and with bush-cutting, their methods and their results, that I wish to deal, especially in reference to how these are affected by natural conditions, and how in return the surrounding conditions are affected by them.

In order to get a clear grasp of these reflex actions, it is necessary to review separately several rather disconnected subjects, and then bring their bearings together as a final clause. So far I have suggested man as an important factor, and the advent of civilised man as a starting point for the more rapid evolution of South Africa's flora and climate.

Natural Causes.

But there are also natural causes at work, far beyond man's control, though still some of their results may be influenced by what man does. I refer particularly to the phenomena connected with climatology—phenomena whose influences are the final factors in plant life and in plant distribution, and on that account I ask the indulgence of Section A of this Association, if I deal at some length with a subject in which Section A and Section C overlap, as a necessary introduction to what follows.

The flora agrees with the climate in every case; a change in the climate brings in its trail a change in the flora, whether that change take the form of adaptation of existing species, increase or decrease in the representation of existing species, or their substitution by other species.

Bolus and Wolley-Dod (1903), p. 231, find that grass burning and bush-fires tend to destruction of species and consequent greater uniformity, but not necessarily greater usefulness of the vegetation, and that the tendency is slowly and gradually

toward the extinction of the ancient flora. But any change in the flora eventually has an effect on the climate also, as I hope to show further on.

Climatic Cycles.

That cyclical changes of climate occur everywhere is now well established—the causes may not be clear or convincing, the duration of the cycle may be irregular and unreliable, but the effects are pronounced, though not always direct, or even easily connected.

The cosmic readjustments which have produced in succession one or more whole-world glacial periods of enormous duration, alternating with periods of more or less torrid equatorial conditions, have rendered necessary gradual readjustments of the flora and fauna capable of enduring each new condition as it came into existence.

But climatic cycles of much shorter duration, distinctly affecting the flora and fauna, have also been established which apparently have their origin in the more or less regular cycles of sunspot production, the periods of maximum activity extending over several years, and by interference with solar radiation producing on earth conditions of less intense light, with consequent effect upon barometric pressure, upon rain production, and upon the vegetation and the fauna.

The Senate Select Committee on Droughts, Rainfall and Desiccation, 1914, reported, *inter alia*, *re* rainfall: "4. (c) That while there is some evidence to support the theory of the periods of maximum and minimum rainfall corresponding with certain cycles, there are not sufficient data available to define any such cycles."

That there occur periods or seasons of heavy rainfall at considerable but more or less irregular intervals, with much drier years or periods intervening, has long been recognised in South Africa as well as elsewhere, and for many years these have been correlated with sunspot phenomena.

Close study in America and in Europe (see writings of Douglas, Huntington, Clements, cited at the end of this paper) place this beyond further doubt, especially as it is fully supported by rings showing annual tree growth for 2,000 years past, and I advise those who still doubt this relationship to investigate the matter further before they commit themselves to opposition views.

The relationship appears to be an indirect rather than a direct one, apparently in the direction of a direct influence on the migration of the baric factors, which in due course, but not everywhere contemporaneously or to equal extent, affect local climate, and naturally not always in the same direction, since if extra pressure exists in one place it corresponds with reduced pressure in another, or, in other words, increased rainfall in one locality corresponds with the absence of rainfall somewhere else.

The sunspots themselves appear with an irregular cycle, which ranges from seven to seventeen years between the

maxima, the number of spots occasionally reaching few or none, then gradually increasing year by year to a maximum varying from 50 to 150 spots, then diminishing again gradually to few or none. With such a wide variation of cycle duration and of maxima, it is, of course, impossible to predict years ahead, but it is found that the average cycle since sunspots could first be counted has been slightly over eleven years, and that the growth-ring records of trees correspond with the known cycles during that period, and so can be accepted as proof for earlier times. What the exact climatic effect is, or how it is produced, may be debated, but it seems that the more spots the less luminous or the more veiled is the sun; that there may be one or more successive years of high or of low sunspot activity; that the whole baric system of the earth is affected thereby in its migrations, and that one result is that hot and comparatively rainless seasons occur when sunspots are few, while duller, colder and more rainy seasons occur when or soon after they are abundant. I say " soon after " because the local action anywhere is not altogether a direct one, and though the migrations of the baric system and of anticyclones, etc., may be a direct action, these sometimes affect local rainfalls one or even two years later, and in methods of local application which, so far as South Africa is concerned, are still far from clear, though this delayed action has been noted in connection with the eastern rainfall.

Although sunspot appearances and reactions have been carefully followed and detailed in connection with the Northern Hemisphere, little has been published concerning these phenomena as they affect the Southern Hemisphere, but just because of the Senate Select Committee's finding, already mentioned, that " there are not sufficient data available to define any such cycles," there is the more reason why this subject should receive the closest investigation, not only as an abstract and interesting theory, but as a proved cause-and-effect elsewhere, and also on account of its intensely practical bearing on the possibilities and probabilities of plant-life and agricultural operations in near future years from any given date, some of the North American States having their cycles of " fat years " and of " lean years " in regard to ordinary agricultural crops, directly related to the weather cycles. In Africa it is clear that Joseph knew something about the result, if not the cause, when he stored grain in Egypt during the several full years, which he predicted would be followed by lean years 4,000 years ago.

All writers on the subject agree that, in addition to the definite sunspot cycles, there are other rainfall cycles, some longer, some shorter, simultaneously at work, the causes of which are less clearly understood, but which crop records and tree-ring records show to be fairly constant, and it is known that when several of these cycles fall due at one time, and occur when due, the rainfall record becomes an unusually heavy one.

The exact correspondence of certain increases and decreases of rainfall (four rises and four falls) shown by Arctowski (1915) during the period 1900 to 1910 for certain stations in Peru, Mauritius, Madagascar and South Africa (Bulawayo) (see Clements, p. 330 and fig. 29), indicate that the Southern Hemisphere has some independent general factor producing simultaneous coincidence in certain localities which is worth further investigation, as also is the distribution of local variations arising therefrom.

In 1888 Mr. D. E. Hutchins published "Cycles of Drought and Good Seasons in South Africa"; in 1890 he brought the same subject before the Royal Meteorological Society, London, and he further dealt with it in the *Cape Agricultural Journal*, 1897, xi, p. 701,* and 1898, xii, pp. 138, 211 and 267. In all these he claims that South Africa is subject to three raintall cycles, of different period, working simultaneously, viz.:—

(1) "Storm cycle, bringing the heaviest rain to western winter rainfalls, but usually only wind to eastern stations. Period nine and ten years alternating" (=Russell's nineteen-year cycle, *Cape Agric. Jour.*, xii, 272).

(2) "Meldrum's cycle, bringing the heaviest rain to eastern summer rainfalls, but usually little rain to western stations." This he previously called "Mitigation cycle"; period, 12·5 years.

(3) Sunspot cycle; period, 11·11 years.—"The least important, or at any rate the least powerful and punctual, of the three South African weather cycles."

These three cycles so rarely fall due at one time that it is 126 years since they were so near together as happened in 1916-1917, which years Hutchins predicted thirty years ago would be a time of unequalled eastern rainfall, in which, at most localities, his prediction has come wonderfully correct, as also have others of his predictions as to rainfall and also as to drought.

The net result of all this, however, is that if Hutchins' theory is on a sound basis (which I neither affirm nor contradict), and apart from any deferred rains which may fall up to 1920, the eastern rainfall may be expected to be less yearly for some years from 1918, and not much again up till 1927-1930, but that the south-west districts should get good rains about 1926, which may extend as storms to the south-east coast also, and that towards the close of the dry period above mentioned intense desiccation is to be expected throughout South Africa, except on the coast belt and sub-coastal mountain ranges, since the rainfall of seasons 1917-1918 and of 1920, which keep the average fairly high, mostly went as

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* Reprinted as an Agricultural Department Bulletin, with corrections, for, unfortunately, p. 709 in the *Agric. Journ.* has many evident printer's misplacements as to due dates.

rapid floods to the ocean, and only a small portion of it soaked in to form a reserve for the next ten years to draw upon. Also it is to be expected that after the few rainfall cycle years just mentioned, another long period will occur before the portions of South Africa fed by the south-east winds will be well supplied again, the cycles getting gradually better distributed thereafter.

That the South African records are insufficient as a basis on which to frame or to condemn cycles suspected to be at work locally is admitted, especially as the summer rainfall records are all upset by being divided into calendar years instead of into seasonal years, but that is no proof that cosmic cycle causes known elsewhere are not active here also: all that is required is that we study and recognise what is going on around us.

I trust, however, that I have made clear how it happens that periods of heavy rainfall alternate in cycles, with periods of intense drought and desiccation; that these cycles are of more or less irregular duration between seven and seventeen years, with average of eleven years; that other cycles of shorter duration are concurrent, but of different average periods and acting differently and in different localities; that when these different cycles happen to overlap, the effect is increased in each direction; and that all these cycles are quite beyond man's power of control.

It is held by some that, if such be the case, it is beyond the power of man to influence in any way the rainfall which nature, through sunspot and other cycles, baric migrations, day and night breezes, and other means, arranges for South Africa; in other words, that what is predestined will happen, and that what is lifted by evaporation from the ocean, whether that quantity be large or small, is what we have to be satisfied with and what we have to take as it comes. That, however, overlooks the fact that the same moisture is often precipitated more than once; that all moisture, either evaporated from the earth's surface or transpired by plants, is then available in the atmosphere to fall again as rain or dew; and that the amount either evaporated or transpired is largely regulated by the vegetation covering the earth. Where there is a dense grass-sward, or a forest humus-bed covered by a forest canopy, nearly the whole rainfall is retained until it either sinks into the subsoil, is slowly evaporated, or else is used by the vegetation and again transpired. Where there is little or no vegetation the surface is usually baked hard, rapid infiltration of rain-water into the soil is impossible, and the result is that almost all the rain that falls there rushes down some river to the sea, carrying soil along with it and producing erosion which in time becomes serious, and not only carries away the flood-water, but also drains away whatever moisture may find its way into the soil and subsoil. It is in this connection that man's influence is greatest.

By grass burning he produces a condition of no vegetation, so for months there is no shade, and for a year at least there is no humus, and, consequently, when rain does fall

there is nothing to retain it: almost the whole supply rushes off to the river; little or none of it reaches the subsoil, and the death of deep-rooted plants results; the small supplies which reached the surface soil soon evaporate, and so the surface-rooting plants die, and the result is that a change of vegetation from mesophytic to xerophytic is inevitable, usually taking the form of a change from red grass (*Anthistiria*) or blue grass to wire grass (*Aristida*).

Repeated burning—whether annual, biennial or at longer intervals—only accentuates the evil, and in the absence of humus protection the half-dry crowns and growth-buds of the better types are scorched or burned, while the xerophytic types adapted to such treatment manage to survive and so become the dominant vegetation.

Summer burning is even more regularly destructive, for though each species has its season of soft growth, more species are liable to damage during summer than during winter, hence "summer burns" often leave their mark for many years.

In what is really good grass-veld there is always the tendency to recover some time if the opportunity is given, *i.e.*, the rainfall and general conditions favour the better kinds rather than the xerophytes, but in too many cases the farmer, finding his veld mostly composed of wire grass (*Aristida*), which is only edible during the first few weeks of its growth, resorts to fire again on purpose to clear off the indigestible old growth and allow stock to feed for a fortnight in spring on the more tender young leaves. Thus it happens that sooner or later the wire grass gives place to bare patches, or to patches of summer annuals or to xerophytes of more pronounced type, the run-off of rainfall is aggravated, erosion begins and the locality eventually becomes devoid, not only of useful vegetation, but also of soil. It is eroded to the rock, and the surface is only covered by whatever disintegrates from the rock below—even that is often washed away in slabs or stones as these become free, instead of being reduced to soil or clay, as happens when the disintegration takes place under dense vegetation.

In a recent pamphlet, "Soil Erosion and Conservation," I have dealt with over-stocking, veld tramping, water concentration and bad farming—all leading to donga formation, erosion, desiccation and desolation in the same way as grass burning, and often acting in concert with that practice.

Thus while under a constantly unburned and undamaged vegetation-blanket humus accumulates and the soil deepens and becomes more and more fit to retain moisture and to maintain the higher standard of vegetation known as plant-succession up to a higher climax type, the reverse is the case where the vegetation is burned off, or tramped off, or over-grazed. What vegetation remains gradually dies off, xerophytes hold the bare surface until erosion displaces both the plants and the soil, and then when the rock is reached even that breaks up by insolation and radiation, and when a flood does happen, these stones, by friction, aid the torrents in causing further erosion. These two courses—the one upward

and the other downward—are the natural sequence of events begun with man's actions, either toward protection or toward destruction.

In the case of forest destruction the change is even greater, for if we look on good forest as the highest climax type, and remove that forest or reduce its canopy without due care as to the rapid recovery or renewal of that canopy, it promptly becomes, through man's agency, either rough grass land or more or less unstable mixed vegetation which is liable to pass into erosion before it ever gets settled into grass-veld, though the latter is its natural tendency if left alone, prior to the next step upward in the succession, which in forest conditions would be forest, if the opportunity were given. But when the down-grade is once begun, man's action hardly ever helps recovery, but much more frequently helps to change the position from bad to worse, till eventually a suitable forest slope is washed to the bare rock, and can no longer maintain any vegetation.

Dr. I. Croumbie Brown uttered this warning very strongly in his many writings over fifty years ago, but the public still ignores the plain fact, and farmers farming stock on what is naturally forest land sincerely believe they are doing the right thing, or following the only possible course, in burning for immediate returns, irrespective of the ultimate result.

Climatic Changes.

Let us now look at the result of this destruction of vegetation upon the climate. Where the process involves the change of a dense canopy and humus, whether of forest or of grass, with its soil-protection and moisture absorption, into a bare surface from which the run-off is immediate and intense, or into any of the succeeding lower stages in which the run-off and erosion are even worse, the atmosphere naturally loses all the moisture, which then goes to form the river flood, or even the river's regular flow, all of which water, when retained by the humus of the undamaged surface, eventually finds its way into the atmosphere and falls again as rain, sometimes time after time.

We can only regard the flood-water and also much of the ordinary river flow as so much water wasted, except in so far as it is used for irrigation or household or power purposes, and we can only regard what sinks into the subsoil, or is transpired or evaporated, as so much water saved for further use. In other words, the less flow to the river indicates the greater saving of water by natural means for further and immediate use inland. I am aware that this is contrary to a common idea that eucalypts, wattles and other trees of rapid growth dry the country, and that this is shown in the reduction of the off-flow. No such drying happens, however, but, on the contrary, wherever the off-flow is reduced that much water is saved from flowing away and is passed into the atmosphere, ready to fall again. It does sometimes happen that these trees tax their sites heavily, which indicates that these particular sites are not well suited for such trees. But wherever the

trees continue to live year after year, that is evidence that they are receiving what moisture they require, and that the channel of escape for the moisture into the atmosphere is a more useful one than when the escape was by means of a river into the sea.

How Much Water is Saved.

A very pertinent question is how much water is it possible to save by this means. The saving in any case is the proportion of the rainfall which does not run off. The larger the area under these vigorous trees, the greater is the saving in moisture and the more is the river flow likely to be reduced.

Then there comes the inquiry: It that be so, how do grass and forest herbage regulate the off-flow required for domestic and economic purposes? It is easy to see that water retained and prevented from running off during rain obtains thereby an opportunity of sinking into the soil and subsoil. The humus of the forest and the humus of decayed grass foliage alike act as a sponge and keep the water till it soaks in. That water may take days, weeks, months or years to be all used by the vegetation, but until it is so used a slow and steady infiltration to some stream or underground reservoir is going on—much more permanent than the flood-and-drought supply of burned veld, but varying in duration in accordance with the demands of the vegetation and the nature of canopy and of humus under which it abides.

Naturally, a tree of rapid growth, and producing little humus or canopy when young, may dry the surface soil considerably, but that drying, when it affects the tree, brings down foliage, makes humus, and produces growth in accordance with the supply available.

How Rainfall is Produced.

But now let us trace that moisture which through transpiration and evaporation again becomes part of the atmosphere.

Temperature, atmospheric pressure and altitude govern what humidity the atmosphere can carry at any particular place; as these change, so also changes the point of saturation, and as soon as that is reached or passed, deposition as rain, mist, dew or snow takes place. Consequently an atmosphere which is capable of absorbing all the moisture that is transpired and evaporated by vegetation many be incapable of carrying that moisture if it happens to meet a colder current, or rises into a higher altitude where the atmosphere is more rarefied. This accounts for the vegetation being different on rising ground from what it is on the flats below, the precipitation on hillsides, and especially on the south-east slopes of the escarpment (*i.e.*, facing the sea breezes) being often sufficient to maintain natural forest which cannot exist elsewhere.

If all the moisture precipitated on these slopes ran off at once to the sea, the country behind would get very little, but, as it happens, a very large proportion is transpired and during dry weather absorbed into the atmosphere and lifted till it again arrives at saturation and falls again as rain or mist.

This is repeated time after time, until the tops of the mountains are reached, which, being cold and rarefied, can produce rain from a lesser actual humidity than happens lower. This accounts for the frequent short rains, the mists and the moisture, which alternate rapidly with drier intervals on the mountains, but which give rise to all rivers or springs rising and flowing steadily in these elevated localities. On crossing the range and descending the other side, or if by chance the descent is made on the same side, climate becomes warmer and pressure greater as altitude is lost, and the atmosphere then is able to carry all the moisture it has brought over the ridge or brought down from the mountain top, unless it happens to encounter a cold current or be driven high enough to again reach saturation, in which case the raindrops or hail-crystals may be formed at a high enough elevation to fall with considerable velocity to the ground.

We already have proved that moisture transpired is moisture saved and banked in the atmosphere. With the foregoing explanation we are now able to see that the more actual moisture there is in the atmosphere, the sooner will saturation be reached at any point, and also the more flow will there be in the overberg rivers and the higher relative humidity in the general atmosphere overberg. That relative humidity may not allow of precipitation as rain, but it produces a less arid atmosphere—one in which plants can live and dew can be formed, a condition which allows of dry-land farming where without that moisture cultivation without irrigation is impossible. We see much of this in the country west of the Maluties.

This atmospheric condition also makes possible the continuous drizzle rains, which do so much more good, and leave so much more soaked in, than the storm-showers which give a deluge for a few minutes, most of which goes off as flood and is lost for ever. Three inches of rain drizzled during three days gives practically no off-flow from good grass-veld or forest, but three inches of rain falling as a deluge during an hour on eroded Karroo does much immediate flood-harm and no permanent good.

A Dry-Blanket.

Even between the Indian Ocean and the mountains, although there are several steps which intercept clouds and so form sour-veld mist belts, the intervening thorn-veld flats and valleys are so protected by a "dry-blanket" (*i.e.*, an atmosphere in which pressure and temperature are sufficient to carry much moisture without reaching saturation) that less rain falls there than on the mountain slopes, and more or less arid conditions prevail, which causes the flora to be either xerophytic or to wilt, since though vegetation transpires freely the supply of moisture from the soil is small or spasmodic. As in all climatic variations, the extremes kill. It is the occasional extreme drought or aridity which controls the flora here, in so far as that is not controlled by fire. Burned veld naturally increases the local aridity, as well as that of all

neighbouring valleys, whereas unburned veld has a surface moisture of its own, affecting not only the local dry-blanket, but also improving matters in these neighbouring valleys.

A very marked case of moisture cut off by the ocean winds being intercepted by a mountain range is the Zambesi delta, including the country from Inhambane to Moçambique, which, being screened from direct long distance ocean winds by Madagascar, has a forest flora of an exceedingly xerophytic leguminous type up to the foothills of the mountains, a condition one would hardly expect in such a climate as this area otherwise enjoys.

Rain from the North.

The rains coming from the north with the annual southern journey of the sun and of the tropical cloud-belt act much in the same way as those from off the sea (*i.e.*, the moisture is carried in a temperature and pressure which can maintain it until cold air or mountains intercept, when rain falls or moisture is deposited). In this way much of the country has a perpetual dry-blanket, in a large area so arid that the name Kalahari Desert has been applied to it, though not by any means unfit to carry xerophytic vegetation, and it is a notable feature that from Johannesburg to Pretoria northward and westward hill slopes having northern aspects have better ligneous vegetation than other slopes, which is the reverse of what happens further south and east. But the presence of that dry-blanket there, as elsewhere, usually brings rain in torrents for a short time only, and seldom as a continuous drizzle rain, when it does happen to rain.

Nature of the Rainfall.

The Senate Select Committee arrived at the conclusion: "That all available evidence goes to prove that there has been no definite diminution in the rainfall of South Africa during historic times." But that there has been variation in the distribution and *nature* of the rainfall is admitted, as also increased desiccation.

Nothing is proved one way or the other in regard to the total annual rainfall, nor can be for a long time, since the long-period recording stations are mostly on or near the coast, and in the south-west or in the Karroo, while the longest-period station is the Royal Observatory, Capetown, which, being both a coast station and one directly included in the south-west winter rain area, is in no way affected by the eastern causes, or by biotic influences at work throughout South Africa.

But increased desiccation produces conditions less inducive to rainfall and to repeated precipitation, and it is difficult to conceive how desiccation can become more pronounced without the rainfall in these dry localities being affected also.

The Senate Select Committee further states: "The evidence as to the progress of erosion and desiccation has been most definite, and the irresistible conclusion is that many parts of the Union, in spite of the apparent constancy of the total amount of the rainfall, have been slowly, but surely, drying

up, the rate of desiccation varying with the differences of locality, soil and gradients, and that such parts must sooner or later become useless and uninhabitable if the process proceeds unchecked." I go further than that, and say that the progress of desiccation is constantly contagious, and that if "many parts of the Union," as stated by the Committee, are drying up and will in time become useless and uninhabitable, then the fate of the balance is sealed unless active steps are taken to turn the tide.

Conclusions.

Let us now draw together all these scattered threads and show how man can affect even the results of the cycles. By maintaining the eastern grass-veld unburned, by maintaining the forests or replacing them by exotic species of more rapid growth and of greater transpiration, and by vastly increasing the area under such exotic trees, especially in the grass-veld slopes and in the natural tree or scrub lands and on the mountains, the amount of saved and redistributed moisture is increased enormously, and so can be precipitated and again absorbed time after time until the mountain faces are clad with forest verdure and the overberg districts can share in the surplus to the extent of enjoying a higher relative humidity, a better vegetation, a more temperate method of rainfall, and consequently less erosion than at present.

On the other hand, by continued grass burning, forest destruction, over-stocking veld tramping, bad agriculture, water concentration and donga formation practically all rain that falls is drained off immediately, and so has a local detrimental effect. There is very little redistributed moisture, and that little becomes less year by year; what moisture is redistributed is insufficient to be redistributed many times, and in consequence mostly does not reach the summit of the escarpment, so that there are less mountain mist and rain, less alpine swamp, fewer and smaller mountain springs and mountain streams, less water running regularly in the streams running either east or west, less overberg cloud, less actual humidity overberg, less drizzle and soaking rain, more destructive storms and hailstorms, and more erosion.

This is not an imaginary picture of what is possible. It is a statement of what is happening now, and I have not the least doubt but that grass burning and bush burning elsewhere have a similar effect to that produced by fires on the eastern slopes.

But carry this further. We know from long experience that we have recurrent alternate periods of drought and of moisture. We have reason to believe that these occur here, as elsewhere, in cycles more or less intimately connected with sunspot phenomena which themselves are quite beyond our control, and are known to have come at more or less regular intervals during the past 2,000 years, and presumably for very many times before that period, so that there is no prospect of their discontinuance. We have shown that protection and extension of the forest and grass-veld produces better climatic

and vegetative conditions, while abuse of the forest and veld produces a destructive down-grade tendency, not only locally, but for hundreds of miles away. We see in many places that, when once that down-grade tendency is started, its natural direction is to go steadily from bad to worse, and when we connect this with the fact that the above-mentioned cycles lead up to extreme desiccation during the later years of the dry period even under present conditions, we cannot help seeing that under continued grass burning and forest destruction that desiccation must not only become more intense annually, but that toward the end of each dry period it must become so much more intense on each occasion that the killing limit for many species must sooner or later be reached, and that even where grass-veld now exists, especially overberg, that must sooner or later be replaced by karroo-veld. Such a change in the vegetation naturally has a reflex action on the climate, which, aided by the continental position of that high-veld, with extremes of insolation and radiation, must further affect the vegetation.

The powerful flywheel of natural sequence, once set in vigorous motion, is beyond the power of man to stop, as is evidenced in Northern Africa and in Arabia; but South Africa is still at a stage in which that flywheel may be started, either in the direction of afforestation and grass protection, leading to upward plant succession, accompanied by general vegetative and climatic improvement, or in the direction of veld fires, forest destruction and down-grade vegetation, reacting on the climate, which again further reacts on the vegetation, until at last the continent is past redemption, as some parts of it now are, and mankind as well as the fauna and flora must die a natural death.

Do not let anyone suppose that what I have had to say goes in any way against the proposals now being urged in reference to bringing the Cunene and the Okavanga rivers into or through the Kalahari. The intention in each case is the same, namely, to increase the absolute humidity of the atmosphere, and so aid plant succession upward instead of downward. Everything done in this direction helps, while the absence of repressive action in regard to grass burning and other causes of erosion is quite as serious and as disastrous to the general welfare of South Africa as is the drying up of the Etosha and other lakes. These two causes acting together threaten the habitable existence of South Africa as a whole. To some I may appear in all this to be particularly pessimistic. I deny that charge, however, and wish to repeat that this is a warning given before it is too late to turn the tide, a warning in which all are interested, whether farmers or townsmen, since if the farmer eventually cannot exist the townsmen suffer also.

I have tried to show in what directions changes in the flora are taking place and are to be expected, apart from cultural readjustments, and what causes are at work producing these changes, and I strongly urge protective action, alike by the Governments and by the individuals; but while not delaying

that action pending inquiries. I urge meantime rapid progress with the work of the Botanical Survey as one of the proofs which sooner or later will again be demanded to show the stability or instability alike of the flora and of the climate.

Meantime, let the destructive agencies be checked or controlled in accordance with scientific reasoning and with common sense.

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SOME ZOOLOGICAL FACTORS IN THE ECONOMIC DEVELOPMENT OF SOUTH AFRICA.

By C. W. MALLY, M.Sc., F.E.S.

With Plate XXIX.

Presidential Address to Section D, delivered July 14, 1920.

In beginning the work of the Section over which I have the honour to preside on this occasion, it seems advisable to call for suggestions for the good of the Section. The programme which we have before us will afford opportunities to discuss subjects on which the authors of the papers have done original work. There may be members or visitors who would like to get information concerning some subject not on the programme or to offer suggestions for the benefit of the organisation of the work of the Section in future. To afford opportunity for inquiries and suggestions, I beg leave to propose that when all the special papers have been dealt with, any available time be devoted to a "Symposium" on any subjects that may be brought forward. My purpose in making

early mention of this is to enable members to note any ideas that occur to them as we proceed and present them promptly to the Sectional Secretary, so that arrangements can be made for any member who has special knowledge of any given subject to lead the discussion. Voluntary discussion is highly desirable as well. I should be very sorry if a meeting of this kind closed without every member having had a chance to discuss any subject in which he or she is specially interested.

Zoological Survey.

It is gratifying to note that steps have been taken towards organising the Zoological Survey. Limited resources in men and means are the proverbial lions in the path, and progress will be slow until they can be dealt with.

Genetics.

The subject of Genetics no doubt occurs to everyone from time to time, and I believe there have been proposals for the formation of a Genetic Society, but so far as I know there has been no practical outcome.

In view of the fact that South Africa has long since been a trysting place for almost every type and race of human being, I venture to say that there is no better place in the world for research on genetic lines. The outstanding problem is that of the intermingling of the races. It is customary to thrust it aside as a matter that had best be left to settle itself, and it may be so; but it is most important. Whether we like it or not, it is a fact, and I feel sure we would be surprised if the rate of intermingling could be determined. My impression is that it is proceeding much more rapidly than we imagine.

From one standpoint the policy might be to let the races blend as rapidly as possible. The negro, for example, is the original type in Africa. It is the general impression that he can withstand the tropical sun better than can the white man, but the white man has superior mental qualities. Assuming that both premises are correct, if it were a mere question of animal husbandry, one would not hesitate to blend the types in the hope of combining the desirable qualities of each in a new type. The fixation of a type, however, requires perfect control over the individuals concerned, so that undesirable units can be eliminated, but in beings acting on their own free will this is not possible. The evidence thus far indicates that in the mass the blending is undesirable, more especially because of the deterioration in mental qualities.

Primary marriages between races should be heavily penalised, because it is a crime against both sides—it destroys them without producing anything as good or better. Each race should have the opportunity of doing the best of which it is capable, but there should be no intermingling.

The manifest desire of the blend is to be considered white. This complicates the problem, because it throws the burden of absorption on the numerically weaker race.

Poverty (and the consequent lack of education) is a powerful factor in the rapid blending of the races. Improved

conditions of housing, livelihood and education will exert a proportionally great influence in keeping the races pure. Accurate records are a great consideration in this regard, and it has occurred to me that in our system of registering births, marriages and deaths we have an unusually reliable source of information, provided it can be made available and properly classified. There are, no doubt, gaps in the evidence from the scientific standpoint, and the sooner any shortcomings along that line are overcome, the better. I would therefore propose that a committee of three or more members be appointed to take the whole subject under consideration and report at the next general meeting.

Big Game.

Civilisation is a merciless eliminating force. It tends to destroy everything not absolutely necessary for the progress of the human race and to create monopolies in favour of essentials. Science is the handmaiden of civilisation in the work of adapting conditions entirely to human needs.

In North America can be witnessed the closing scenes in the great drama in which the red man, the bison, the deer, the bear, the opossum and the coon are being annihilated in favour of the introduced types—the white man and the negro, the horse, the cow, the pig, the sheep, the goat and the hen.

In Africa the same process is being repeated. Although published long ago, before anyone dreamed of a "big game" problem in Africa, the accompanying illustration (Plate XXIX) makes it easy for one to imagine all the principal types in conference over the possibilities of annihilation at no distant date, and the zebra and the gnu appear to have suddenly made up their minds to escape the clutches of fate if they can. Why are they all in danger of annihilation? Simply because they are apparently not essential to the welfare of man. Not only that, they are a positive source of danger from the standpoint of diseases that can be transmitted to human beings. Under such circumstances, viewed dispassionately, it seems inevitable that, however much one would like to preserve them, the African types, with the possible exception of the ostrich, will have to give way in favour of the same domestic types that are now everywhere dominant in Europe and America.

I feel constrained, however, to utter a word of warning. These old types have survived all the vicissitudes of the ages, and even now the chief charge against them is that they are the natural reservoirs of pests and diseases under whose onslaught we perish. Does it not seem likely that thorough research on the reaction between the original types and the pests and diseases may lead to important discoveries on the question of immunity or resistance? They may carry with them an important secret which, discovered before it is too late, may be immensely valuable in connection with other problems. While the process of elimination is going on we should make sure that valuable evidence does not disappear. If possible, colonies of all types

should be preserved under conditions which will not permit of their being a source of hindrance or danger to human beings.

On the Value of Zoological Illustrations in School and Popular Books.

Over forty years ago a scientifically illustrated school geography was published in the United States. Fortunately for me, a copy fell into my hands, and from it I gained, not only a vivid, but a correct impression of the zoological features of physical Africa. In the accompanying reproduction of the page relating to Africa (Plate XXIX) the outstanding types are grouped around descriptive matter in a way that could not but serve as a wholesome stimulant to the imagination and inspire a desire to know more about the animals and the country in which they live. As an illustration, it is quite the best thing that has ever come to my notice in a school book. I deem it worthy of reproduction because it gives a good idea of many of the animals whose fate is at stake in our "big game" problem, and also because it may be helpful to those who have the responsibility of preparing school books. It is often through a medium like this that a love for knowledge for its own sake is inspired. Animal life makes a powerful appeal to young and old alike, and illustrations should be used to the utmost to enliven what may otherwise be dull and uninteresting subjects—zoology and geography.

In this connection, I would plead for greater regard for truth in illustrating children's picture books, which are published in such lavish fashion. Pictures of animals distorted into impossible attitudes, arrayed like human as well as other kinds of beings and attempting the weirdest possible pranks, are too often the rule. In some instances there is no doubt a lack of exact knowledge on the part of the artist, and an appeal to the ridiculous provides an easy way to disguise superficial knowledge and turn it to commercial advantage. The life story of any given animal is sufficiently fascinating without fictitious embellishment. It is a great pity that a child's first impression should be misleading. At the same time, it must be admitted that works of reference containing reliable data to which artistically-inclined persons can turn for exact information are seldom available except in university and technical libraries. Furthermore, the details of the life story of most of our wild animals have never been recorded anywhere. How many here to-day can describe the development of the rhinoceros or the hippopotamus or the giraffe from birth to maturity? Every facility should be given for the illustration and publication of observed facts concerning animal life, more especially of such types as are in danger of becoming extinct. The eye should be appealed to as much as possible, but the aim should be to give correct impressions, and thereby avoid the worse than waste due to a misapplication of artistic ability. The author of my favourite plate certainly reflects the touch of inspiration, for not only are the animals faithfully depicted, but the pyramid and the ruin stimulate speculation in regard to the secrets of the past, and

the rising sun—shall we say of modern science?—bespeaks the beginning of a new era for

The Dark Continent.

In the expansion of civilisation under the influence of Christian ideals, the outstanding fact is that the trend was north-westward into Europe, where it gradually gained force and in time spread like a tidal wave to the American continents. In Russia it subsided, as in a morass, in the great aggregation of widely divergent elements that comprise the nation, and in Asia it was impeded by the inertia of a people imbued with the ideals of an older civilisation that had apparently reached a state of equilibrium. To the south-west stretched the great continent of Africa, in which profuse natural resources were apparently available for the asking, but for some reason they were left almost in abeyance, save for the slave trade, which attracted world-wide attention. Why did the tide of Western civilisation cross three thousand miles of water and develop the American continents rather than follow the coast-line of Africa and extend its scope to inland resources that even now are the admiration of the world? The query might be answered by saying that it followed the line of least resistance. But that suggests the further query: Why was North America more easily mastered than Africa?

North America and Africa Compared.

In North America the virile races of Europe found a native race which, though virile in many ways, was not capable of adapting itself to new conditions, and hence it disappeared and left the new arrivals free to develop to the fullest extent. Besides a great expanse of fertile soil and an invigorating climate, regular seasons and adequate rainfall, natural resources in the form of water-power, forests, coal, iron and oil, not to mention gold and silver, were easily available. It was inevitable that, under the combined attack of the best races of Europe, inspired by high ideals, such a continent should come under control rapidly.

In Africa the same European races attempted the conquest of the continent, but in place of it becoming an asset, it proved to be almost a barrier thrust into the ocean to hamper communication between east and west. Why did they not boldly invade and hold the continent in place of going around it for generations, or, at best, holding on precariously at certain points?

In comparison with North America, the natural resources of Africa were not easily available on account of natural obstacles—great desert belts in certain parts contrasted with great swamps and jungles in others; irregular rainfall, resulting in floods, followed by droughts and scarcity of food for the millions of natives that were ever present and capable of adapting themselves to new conditions; in general, a "climate" that had (and still has) a great reputation for being "deadly." Under such conditions it seems inevitable

that progress would be slow. But if we accept the evidence of ancient workings for the recovery of gold and of the ruins still in existence in the area where we have the pleasure of holding our meeting to-day, the attacking forces overcame obstacles, penetrated far inland and made determined efforts to master the country. Why did they not persist? The deserts, the swamps, the mountains and the rivers were gradually crossed and recrossed, but the "deadly climate" remained inscrutable till the progress of science at last shed a flood of light on the whole matter by proving that its deadliness was not due to conditions in general, but to the presence of certain definite destructive agencies. In the light of our present knowledge there is no reason to doubt that these agencies have been present in their natural African reservoirs since time immemorial, and that they were largely responsible for impeding the progress of civilisation on the continent as a whole. It is my purpose on this occasion to call attention in broad outline to certain factors in the development of South African resources, in the hope of stimulating discussion on the advancement of scientific research in connection herewith, for it is apparent that Africa is destined not to yield except to the pressure resulting from the application of the combined experience gained by scientific workers throughout the world. In coping with Africa, one may well ask whether the strongest is strong enough.

Entomological Research in its Relation to Human Welfare.

Human Diseases.

It is only necessary to mention the alliance between sleeping sickness and the tsetse fly; malaria and yellow fever and the mosquitoes; typhus fever and the louse; typhoid, dysentery and other diseases and the house fly, to impress even the most sluggish intellect with the fact that there is great need for thorough research into the question of human diseases and the agencies that disseminate them.

Independent of any question of the transmission of disease, there are two insects—the louse (*Pediculus humanus*) and the bedbug (*Cimex lectularia*)—that deserve special attention on account of their influence on the efficiency of labour.

No human being can rest properly under an infestation of either lice or bedbugs, or both, and it seems reasonable to suppose that the disturbance will be reflected in working capacity and be in direct proportion to the degree of infestation. I have frequently received requests for help in combating either one or both of these pests, and the degree of infestation found on careful inspection surpasses imagination. It is no uncommon thing to find Kaffirs sleeping on the ground in the open air rather than brave the swarms of bedbugs in the huts or barracks. Cattle and sheep are dipped for ticks and scab "because it pays." I submit that it will also pay in the increased efficiency of labour to fumigate the clothing and the sleeping quarters of the lower classes with prussic

acid for the destruction of lice and bedbugs. The State owes it to itself as well as to the poor people concerned to see that such an easy means of control is adopted.

Animal Diseases.

Animal diseases such as East Coast Fever, nagana and horse sickness—especially the latter, which for over a quarter of a century has baffled every effort to determine its natural transmission—serve to illustrate the need for research along that line.

Agricultural Pests.

Maize Insects.

While reviewing the subject of maize insects recently, I was impressed with the fact that prior to 1900 comparatively little interest was taken in the pests that attack maize. The only explanation that I can suggest is that maize did not always hold its present important position in South Africa.

Twenty-five years ago, for example, there was no export trade in maize, and hence the supply no doubt often exceeded the demand. Under those circumstances insect injury would be passed over as of little consequence. The live stock industry, which now makes heavy demands on the maize crop, was languishing under the burden of rinderpest, lung sickness, horse sickness, sheep scab and tick-borne diseases—redwater, heartwater, East Coast Fever. Locusts made periodic inroads, and on account of their spectacular nature attracted popular attention everywhere. In fruit-growing districts and in the towns the Australian bug (*Icerya purchasi*) caused a great outcry, and the grape *Phylloxera* even brought about a change of Government. In the midst of plagues that caused such violent political as well as economic upheavals, the insect pests of maize must have seemed such modest creatures that they were passed by as not worth notice.

Value of Maize in South Africa.—Some idea of the value of the maize crop in South Africa can be gained from the following official Crop Report Estimates:—

1910 ...	(Census taken in 1911) ...	8,632,516	muids
1911 ...	Estimate ...	8,482,700	..
1912 ...	do. ...	8,121,200	..
1913 ...	do. ...	8,000,000	..
1914 ...	do. ...	8,512,300	..
1915 ...	do. ...	10,250,000	..
1916 ...	do. ...	8,500,000	..
1917 ...	do. ...	11,800,000	..
1918 ...	do. ...	9,600,000	..

The total yield for the nine (9) years was therefore ... ... 81,898,716 muids, and the total value, at 9s. per muid, was £36,854,422.

The average annual yield was 9,099,857 muids, which, at 9s. per muid, amounted to £4,094,935.

Annual Loss Due to Certain Maize Pests.—Of the insects that attack growing maize in South Africa, the stalk borer, the cut worms (near relatives of the preceding), the ear worm (*Chloridea obsoleta*), the black beetle (*Heteronychus arator*), and the snout beetle (*Strophosomus amplicollis* Fhr.), are the ones of outstanding importance from year to year. It is impossible to give an exact statement of the actual loss caused by these insects because of the difficulty in getting accurate statistical records, but all available information warrants my estimating that there is a total annual loss of at least 25 per cent. for the few pests mentioned.* The average annual yield of over nine million muids is therefore only 75 per cent. of what it would be if it were not for the insects. Hence the total loss may be calculated as 3,000,000 muids, which, at 9s., amounts to £1,350,000, of which stalk borer alone is responsible for 1,200,000 muids, valued at £540,000. At this rate, if insect injury to maize could be eliminated, it would, in two years' time, reimburse the country for the cost of the proposed elevators for handling the grain crops of the Union.

The loss, though great in the aggregate, is distributed more or less evenly over the farms in the maize-growing districts, and hence the nation little realises the extent of the burden. The loss is virtually an indirect tax levied on the public through the farmers. The farmers would certainly be up in arms if the Government proposed to raise such an amount by special tax on the land employed in the production of maize, and yet the stalk borer and a few other insects inflict the burden annually while many farmers remain indifferent to the situation. Under the circumstances, it is highly important to inquire what can be done to prevent so great an annual loss. The only sound proposition is to urge the endowment of research and demonstration work on the full economic possibilities of the crop as a whole, so that all factors entering into the production of the crop can be elucidated and the information brought home to those who are in position to make use of it.

Wheat Insects.

On account of its intimate relationship to human welfare, wheat occupies a unique position in the list of cultivated plants. Anything that touches wheat is at once a factor of world-wide importance. All over the world some of the most difficult insect problems centre around this important crop. In South Africa the wheat louse (*Toxoptera graminum*) undoubtedly deserves first place from the practical standpoint. In the coastal belt of the Eastern Province a black sheep amongst the ladybirds (Coccinellidæ), *Epilachna similis*, is a serious pest at times.

In the Western Province, Hemiptera, especially *Blissus diplopterus* Dist., often do far more damage than is frequently supposed. In all cases a solution depends on thorough research work.

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* For detailed information, *see* Official Report on the Maize Stalk Borer (1920), by C. W. Mally, Senior Entomologist, Union Department of Agriculture.

Olive Insects.

In view of the highly favourable natural conditions, South Africa should have the finest olive groves in the world, but there are two little insects that serve as effectual deterrents—the Olive Tingidid, *Teleonemia australis* Dist., and the Chrysomelid, *Pseudococcinella sexvittata* Chevr. When it has been demonstrated that the control of these two species by either spraying or fumigation falls within practical limits, olive culture should go ahead by leaps and bounds.

Other Species of Importance.

To continue with even a brief survey of outstanding problems would require an undue amount of time; but even so, attention must be called to the fact that the vine has its mealybug, every tree and bush its scale insects, the wattle its bagworm, and the veld its termites. All are replete with scientific as well as economic interest.

Fluctuations in Relative Abundance of Insects.

No insect species is uniformly abundant from year to year. Some fluctuate far more than others. The American Army Worm, *Leucania unipuncta*, and the South African Mystery Worm, *Laphygma exempta*, are species in which extreme fluctuations occur, a season or two of extraordinary abundance being followed by a series of seasons of almost total absence and then a sudden increase to excessive abundance again. With other species the fluctuations are not so violent, but they are fairly well marked. Unfortunately there is no really satisfactory way of explaining them. One thinks at once of natural enemies in the form of parasitic insects, diseases and unseasonable weather. Climatic conditions coupled with excessive abundance may possibly affect the vitality of any given species, which after a time resumes full vitality and makes its influence felt accordingly. Variations in farm practice may help or hinder a species. It is highly desirable to determine the exact causes of these fluctuations, for through the knowledge we may find a clue to easy control measure.

Beneficial Insects.

Beneficial insects are important factors in human welfare. Whether concerned in the production of human food in the form of honey and the distribution of pollen to ensure the cross fertilisation of flowers, or whether they are acting as internal parasites or external enemies of injurious insects, they are all contributing their share towards making and keeping the earth a fit place for human beings. Although a few species are fairly well understood, the great majority of named species mean little more than names to us. In fact, we have scarcely touched the fringe of the great problem of parasitism and the possibility of controlling injurious species by means of their natural enemies. This phase of entomological work will increase in importance as the increase in population necessitates the utmost economy in the production of food. The study of

insect parasitism is slow and tedious, and hence no time should be lost in doing the utmost possible to perfect our knowledge along that line.

Results Achieved.

Thus far attention has been paid to unsolved problems; but lest someone get the impression that no results of practical value have been achieved, I shall emphasise the fact that certain problems have been brought to the point where control is possible. The elucidation of the life cycle and economy of the bont tick in its relation to the disease known as heartwater in sheep and goats and cattle has made it possible for the merino sheep and the Angora goat to be brought back to the farms which farmers left in despair 25 or 30 years ago. A detailed knowledge of the ticks concerned in the transmission of East Coast Fever in cattle has made it possible to prevent the disease sweeping like a blight over the stock-raising areas.

At one time the wine and grape industry was threatened with extinction from the grape *Phylloxera*, but the discovery of a resistant stock saved the situation. The Australian bug threatened the life of the citrus industry and a wide range of other plants as well, but the introduction of its natural enemy (*Novius cardinalis*) turned failure into success. The peach trees were smothered with white scale (*Diaspis pentagona*) and the prune industry languished under the burden of the Bryobia mite, till a critical study of the old California lime-sulphur-salt wash showed the polysulphides to be the essential ingredients. As a result, we now have an almost perfect insecticide in commercial form, not only for the tree pests named, but for sheep scab as well. The fruit fly was thought to be of such importance that one farmer declared that if anyone found a way to control it, he would write his name in gold all over South Africa! A means of control was found in due course, and the fruit-growers have received ample returns in golden sovereigns; but the golden promise has been all but forgotten. Through the use of arsenite of soda, locusts, which once held sway, no longer hatch and feed and take wing at will in swarms to darken the heavens like an emblem of Divine displeasure to inspire the timid with fear.

Let it not be imagined that because I used the expression "results achieved" I consider that there is nothing more to be done. Far from it! The true position is that we have reached a stage where we can control certain pests to advantage. Still more efficient means no doubt await discovery or application to present conditions. As hinted in an earlier paragraph, the sun is only rising. For 25 or 30 years we have been using prussic acid (hydrocyanic acid gas) for the destruction of insect pests by fumigation, and the process seemed practically perfect. Circumstances arose which indicated the possibility of improvement, and a search through the literature revealed the fact that at the beginning of last century it was demonstrated that the gas could be reduced to liquid form by cooling. The application of this to modern conditions has revolutionised fumigation and placed it on a more nearly scientific basis.

As might be expected, Africa presents exceptional difficulties, but we are not without hope of ultimate success.

The Secret of Success.

The portions of the virile races of Europe that attempted the conquest of Africa were held at bay. No blame attaches to them. On the contrary, all honour to them, for the wonder is that they were able to hold out till Science could come to their aid.

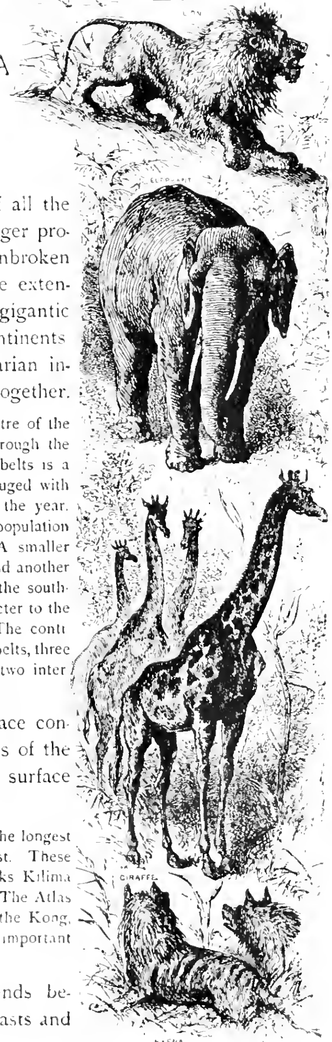
There is no gainsaying the fact that on the whole success has been achieved through scientific research, not by the proverbial man in the street, but by men from foreign countries who, through years of study in institutions of learning, had acquired special knowledge and responded to the call of Africa, and applied themselves whole-heartedly to the task of overcoming what seemed like insuperable difficulties in the way of progress.

A Plea for the Endowment of Educational Institutions.

The knowledge requisite for the solution of scientific problems does not come from nothing. It is a gradual accumulation in storehouses that we designate schools; colleges and universities. It is these institutions, inspired with a love of knowledge for its own sake, that we have to thank for the men who can go forth and grapple successfully with the unknown. These institutions must be made the centre of our national life, and the view must be broad so as to prevent the narrowness peculiar to those of limited outlook. Our young men and women must be given a fair chance to prove themselves. Thus far their record stimulates a feeling of pride, and we may confidently look forward to the day when they will hold their own, not only in this country, but also in an international exchange of men.

Such being the case, I submit that it is only the part of wisdom to make every possible provision in the form of endowment for our educational institutions, so as to secure the highest possible efficiency in training those who show that they have ability. Our system of education should be like a huge net, in which every young person is caught up and brought within reach of the lines of force of the university magnet. Rest assured, the ear of the teacher will not fail to hear the "click" when young men and women strike the lines of work that appeal to them. Then is the time when special encouragement in the form of scholarships should be available, in order that no case of real merit need recede into obscurity for lack of means to continue to the stage of national usefulness.

South Africa should invest heavily in scientific research, for that is the only way we can hope to hold our own against nations with easier conditions. The more difficult the work, the stronger and better trained must be the men. Thoroughness of preparation, even though extra time is required, should be encouraged by the prospect of adequate remuneration when work on practical problems is undertaken. And yet university



PHYSICAL AFRICA

CVII.

DESCRIPTION.

1. Africa contains about one half of all the land in the Torrid Zone. It has a larger proportion of plateau surface, more unbroken coasts, a hotter and dryer climate, more extensive deserts, and more numerous and gigantic animals than any other of the six continents. It also has a greater number of barbarian inhabitants than all the rest of the world together.

The northern tropic passes through the centre of the Great Desert, and the southern tropic through the Kalahari Desert. Between these desert belts is a broad fertile region, most of it being deluged with tropical rains during several months of the year. This belt contains the greater part of the population and of the vegetable and animal life. A smaller fertile belt is found in the Atlas region, and another in Cape Colony. The Great Karroo, in the southern belt, is a low plateau, similar in character to the llanos and pampas of South America. The continent has therefore five parallel physical belts, three of them broad tracts of fertile land, and two intermediate ones of desert.

2. **Surface.**—Nearly the whole surface consists of broad, low plateaus. The edges of the continent are partly bordered and its surface broken by short mountain ranges.

The highest plateau is that of Abyssinia. The longest mountain ranges lie along the eastern coast. These mountains contain the snow-covered peaks Kilima Njaro and Kenia, the highest in Africa. The Atlas Mountains, near the Mediterranean, and the Kong, near the Gulf of Guinea, are the only other important ranges.

3. A narrow strip of lowland extends between the mountain borders and the coasts and

Page from "Harper's School Geography." Published in U.S.A. in 1876.
(Considerably reduced.)

training is not everything. "Though you bray a fool with wheat in a mortar with a pestle, yet will not his foolishness depart from him." Rather have an untrained man with ability than a fool with a degree. In this connection we must recognise three classes of men: (1) the self-made man; (2) the university-made man; (3) the university man-made man. A generation ago the self-made man in science could still be found, but to-day he is a rare specimen. The vast majority of those who pass as such come under the influence of trained men, from whom they learn and in course of time become proficient and achieve well-merited recognition. But the indispensable nucleus is the man who has come under the sway of our institutions of learning and has a thorough grasp of the problems of the day. A certain number of untrained men can be absorbed, but be it not overlooked that they are a side-draft on the load until such time as they become efficient. Increase their number, and the inevitable result is to reduce both speed and efficiency and to discourage the men who have spent time and means in preliminary training. That is all the more reason why facilities should be available to enable the man of great natural ability to be trained and thrown into action without the exhausting struggle against odds for years. The probabilities are that whatever success he achieves in his own strength will be small in comparison with what he could have done had proper facilities been available for him in his younger days. No system of education can create ability, but it does enable each man to do the best that is possible for him. The outstanding man becomes more outstanding and the average man who otherwise would never be heard of at all is made available for a wider field of usefulness.

Ample financial means exist to enable every man or woman of every race to attain his or her limit of achievement, but the difficulty is to arouse such a thorough popular interest in the national welfare that they will be made available.

In the past progress has been slow because it has depended on the devoted few. If progress is to be more rapid in future, South Africa must endow its schools, colleges and universities more liberally and see to it that conditions are such as to attract able men and women to its service.

I am sure you will all agree that thus far science has done much for South Africa. It remains to be seen what South Africa, in its own interests, will do for science.

THE MAGIC CONCEPTION OF NATURE AMONGST BANTUS.

By Rev. Henri A. Junod.

Presidential Address to Section E, delivered July 15, 1920.

When I was asked to be President of Section E of this Association, an ideal of a Presidential Address rose before me. It should, in my opinion, have as an object at least the opening of new ways to anthropological research. But in my position, living on the veld, far away from any library, without books and reviews as aids, the ideal could not be attained; so I simply consulted my experiences of thirty years with South African natives to see if I could not draw from these experiences some remarks which might be useful to others. I think that I found what I wanted, and this will be my modest contribution to the solution of the, as yet, unsolved problem of South Africa—the native question.

The coexistence of the European Aryan race with the Bantu race in South Africa has created a situation which certainly has its advantages, but which is fraught with many dangers. Whatever the future may be, there is no doubt that for the present the white race has to rule and guide the black race. I think that we have courageously undertaken that task—perhaps more heartily than natives themselves should wish. But I venture to put the question: Are we really and deeply influencing our black fellow-citizens? Are there not insuperable difficulties in the way?

Considering first the religious domain, I dare to state that the influence is real, and it is spreading rapidly. The Bantu has a strong religious disposition, and the ancestor worship which he practises affords little relief to his soul, which longs for life and happiness. The Christian God very easily supplants the ancestor god in his prayers. Even if he does not accept him, he rarely makes objections to his existence. The "Father Who is in Heaven" possesses all the good features of the ancestor god, and a good many others, and he asserts himself at once as superior to the spirits of the deceased forefathers. The Christian religion is bound to conquer the Bantu in a comparatively short time.

That is not to say that people emerging from the mists of Animism can at once grasp the full meaning of Christianity. We must always remember that the Bantu creed does not establish any connection between religion and morality, whilst Christianity, at least under its pure form, is essentially a moral religion. It often happens that converted natives pretend to enjoy religious privileges and cultivate religious emotions without leading the pure life which Christianity asks from its adepts. On account of this disposition, those who conduct native churches have to be

constantly on the watch lest the high teaching of the Christian religion becomes deteriorated amongst them. Yet missionaries, as a rule, believe in the conversion of the Bantu tribes. They feel that their message has obtained a real hold on thousands of natives, and this is perhaps the reason why they are more sympathetic to natives than any section of the white population.

But the predication of a new and higher religion is not the only duty of the white race towards the black one. The white man has to rule and to educate the native population; he must consequently exert a considerable amount of authority over it. I will not dwell on the political side of the question. It may be asked to what extent the staff of the Native Affairs Department really controls and influences the natives. They obey. They cannot help obeying, because they have been conquered. Is the sovereignty of the European accepted with a contented heart? I am not quite sure of it, and I think that even in the most loyal natives, in the background of their brains or in the bottom of their hearts, there always remains the dream of a Bantu Napoleon who will appear some day and reconquer the land of their fathers for them. This is a burning question. I may only state that in late years criticism of white methods of government has been more and more prevalent, and one thing is sure—the treatment of natives, politically speaking, must be fair and as liberal as possible if we want to preserve the peace of the land.

I prefer speaking of things I know better, and which are not so dangerous to discuss. To what extent do natives submit themselves to the authority of those persons who try to guide them in a totally disinterested manner—for instance, missionaries at the head of native congregations or principals of native institutions? I leave aside the case of employers on purpose, in order to make the demonstration more convincing.

Let us be just. Our authority, which is purely moral, which does not rest on any external constraint, which is not backed by any material sanction, is generally well accepted by our converts or by our pupils. However, one must be very cautious if one intends to be obeyed. The white master will be wise if he presents his decisions under the shape of advices rather than of orders, especially if he wants to enforce anything new, not yet consecrated by custom. He must also be careful not to trespass upon the native laws of "etiquette," and amongst them the law of "tibisa," viz., of giving official information in due time. Should you put a decision into execution without having fully explained all the matter to your natives, you are sure to meet with trouble. These exigencies, after all, can be accepted by the white master, however tedious and useless they may sometimes seem to him. They are part of a sound and sane native policy. Let us respect the peculiarities of the native mind, as long as there is nothing really wrong in them.

But cases will happen when, though you have observed all the rules of their parliamentary etiquette, your boys will

refuse to obey. Though your orders are perfectly reasonable, in full agreement with the principles your pupils themselves profess, they will not accept them. How is it possible? Some of them, probably those who are less commendable, are opposing your will, and they have taken hold of the others; the whole class now forms one body, and it will begin to fight. You may say that such a rejection of authority may happen everywhere, amongst all the races. But here is the peculiarity of the Bantu—as they are all agreeing, they are convinced that they are right. You may appeal to their reason, to their conscience. No avail! The fact that they are all of one mind is for them a sufficient justification of the position they have taken. This is very curious, and evidently comes from the habits of their former tribal life.

How is a decision taken in the courts of Bantu chiefs? There is much discussion first. Everybody has the right of explaining his thought. The Bantu court is eminently democratic in this respect. Little by little a general opinion forms itself, and when it becomes preponderant the chief "cuts the matter," as they say, according to the feeling of the majority. There is no voting, no minority. Nobody, after the chief has spoken, would dare to think that he may be wrong in submitting himself to the dictum of the assembly. There is no such a thing as scruples of conscience or faint ideas that the decision may not be in harmony with moral principles or with divine will. The horizon of the Bantu mind does not reach such distant spheres.

I am sure that this is the psychical explanation of the difficulties we often meet in guiding our native pupils, and it accounts for the terrible acts of insubordination which we sometimes have to deplore. This shows that a good deal of supplementary education is wanted to elevate the Bantu mind from the juridical conception of good and evil to the spiritual notion of morality taught by the Christian religion.

The best plan to adopt in such circumstances is to try to persuade one or two of the better boys—to awake their sense of duty. This is very difficult, as it appears to them that by yielding they would be traitors to the common cause. However, one may occasionally succeed, and then the resistance will fall at once. I remember one day having reached that aim. The pupils of the institution wanted the programme of the school to be amended according to their wishes, and their demand was not altogether unreasonable. But I had to tell them that such a change could not be made by myself, but only by the conference of missionaries which controlled the institution and was alone competent to decide the case, to the exclusion of anybody else. But they insisted that they should be satisfied immediately. They were threatened with expulsion, but they were prepared for that extremity, and already were going to pack their little luggage. One of them, however, began to see that they were decidedly wrong, and he agreed to stay and to accept the postponement of the decision. This secession broke the strength of all the others.

One of the principal opponents said with a sigh: "I see that we black people are totally unable to reach our ends. We are no longer of one mind, thus we are wrong, and we must yield and ask to be forgiven." This boy was one of the best Christians of the whole lot, but a typical Bantu.

But I take a step further, and beg to state that the fundamental difference between the European and the Bantu mind—the difference which mostly prevents a true understanding of the one by the other is this: We Europeans of the twentieth century possess what I may call the *scientific spirit*, whilst Bantus are still plunged in the *magic conception of Nature*. This is the proper subject of my address. I enter now the domain of ethnography, properly speaking. My preceding remarks applied to the native who has already been more or less transformed by our religion and by our schools. We now consider the raw native who has not yet received any education. Needless to say, at this present time the heathen type is still infinitely more numerous than the Christian variety.

I say that we Europeans of the twentieth century pretend to possess the scientific mind. We study phenomena; we notice that a first phenomenon is followed by another. We try to discover the relation between them. We perhaps come to the conclusion that the second is produced by the first. Applying the category of causality, we then assert that the first is the cause of the second. But we do not hasten to draw the conclusion. We first examine, cross-examine, analyse, and only when we are sure do we pronounce our judgment as regards causality. Take, for instance, phthisis. The European scientist has not been satisfied before he has found that the lesion in the lungs is connected with a particular microbe, which enters the human body in such and such a way, and whose progress is concomitant with the progress of the disease which it causes. Owing to the knowledge acquired by observation, a scientific treatment of the illness is henceforth possible.

The Bantu mind proceeds on quite different lines. As a rule, a Bantu does not bother very much about causes. He accepts the world as it is, without asking who made it and why things are as they are. However, when phenomena make him suffer, he wants to know where such abnormality comes from—be it disease, drought or accident—and, having never inquired scientifically into such phenomena, he at once believes that they are produced by spiritual agents like himself, be they ancestor spirits or spirits of living persons which possess the power of witchcraft. And now, when it becomes imperative to fight against such influences, he resorts to magic. Magic practices are based on a certain number of principles which are self-evident to the Bantu and which dictate most of his actions in dealing with disease and other misfortunes. The most important is the *principle of similarity*, which is at the root of what ethnography calls "sympathetic magic." As long as two phenomena resemble

one another, they react on each other. Like acts on like. Thus a certain remedy will cure a certain disease if it resembles it in one way or another.

Let me give some examples, to make clear this magic mentality of the Bantu as opposed to the scientific mentality of the modern European.

A magician has had the good luck to discover a crow's nest full of young. He climbs on the tree, and ties all the little birds together by their feet. The mother crow, however, is not at a loss to deliver her progeny. She brings each day a leaf taken from different trees, and puts it in the nest. The magician keeps watch. He climbs, looks at the leaf, and recognises the tree from which it has been taken. He goes and digs a bit of root from that tree. After a few days he will have quite a bundle of various roots. By that time the little crows will be free, the string which was binding them having given way, and the magician will possess a medicine of first quality. By means of it he will be able to deliver any patient from any disease or worry tying him. This is pure magic, magic of the nice kind, as it is intended to help and to cure—white magic, we may say—whilst black magic is the one which intends to kill by the same proceedings.

Another example is as follows: A Ronga of the clan Timba, which is the great clan of hippopotami hunters, has succeeded in throwing an assagai into the back of the huge black beast. The assagai was tied by a long string to the nervule of an immense palm leaf. When the hippopotamus was wounded, it at once plunged into the water, the string unrolled itself, and the big nervule, similar to a pole twenty feet long, remained floating on the surface, being dragged along by the beast in its attempt to escape. Now the real chase would begin, and it would be fraught with many dangers. At that very moment a messenger is despatched to the hunter's wife in his village not far from the river. She is told to go at once and shut herself in the hut, to sit down and keep perfectly quiet. If she does so, the hippopotamus will be easily killed. It will not be too wild, it will not fight too hard, and soon it will be possible to throw another assagai between its nostrils. The animal will be unable to close them any more, water will penetrate the lungs, and it will die. This is magic. The quiet demeanour of the hunter's wife will cause the animal to be quiet.

Another example borrowed from the agricultural customs may be given. Stealing mealies in the gardens is of common occurrence amongst certain tribes, but it will be prevented in the following way: The small nervules of another palm tree called "rala" are taken. These nervules are like little sticks, and are very flexible. They are called "tinhlamalala." At the extremity of each of them a knot is made. Then a snake's skin is sought—I mean an old skin, which the snake has cast. It is burned, a powder is made out of it, and the sticks are smeared with it. Then the sticks are woven together, and something like a crown is made out of them.

This crown is put on one of the mealie stalks. Now, should a thief enter the garden, these tinhlamalala sticks will all be transformed into the kind of snakes which also bear that name of tinhlamalala. They will angrily attack the intruder, who will fly and throw away the cobs he has already stolen. Notice here a double similarity which makes the remedy all the more effective—the similarity of form—the slender nervules with a knot at their extremity resemble a snake with its head, and the similarity of name—both the nervules and the snakes are called by the same name, tinhlamalala.

All nonsense! every reasonable person will say. This will never happen, of course. But that is not the question. The important thing is that the native will believe it at once, as the story is quite on the lines of those magic principles which are evident, unquestionable to his mind.

Hundreds of cases like these might be quoted. The life of the Bantu is full of magic. It is at the base of all his pharmacopæa, of most of his hunting and agricultural customs; it mixes with his religion. But nowhere does the power of these magic principles appear more plainly than in the well-known custom of

Bone Throwing.

I have devoted considerable time to the study of that practice amongst the Thongas, and found that it is impossible to exaggerate its importance in the social, moral and religious life of the natives. The throwing of bones—hlahluba in Thonga, tungula in Venda—is both a splendid illustration of magic, as it is entirely based on the principle of similarity, and the most elaborate product of the magic instinct.

Amongst tribes of the Suto group the divinatory bones are mainly four in number, being four bits of carved ivory or bone, two male and two female. Amongst Zulus and Thongas the bones are mostly astragalus bones taken from the legs of different animals, a number of different objects being added to them. The famous basket of the bone-thrower, such as I received from one of my best informants after he had initiated me into his wonderful art, must be shown. The contents of the basket are very varied. Sometimes as many as fifty different pieces are found in it.

There are first the astragalus bones taken from the legs of domestic or wild animals. According to the law of similarity or of correspondence, the *domestic animals* will represent the *inhabitants of the village*, whilst the *wild animals* represent the various powers and influences of the *bush*. Astragali of goats are the most numerous. The he-goat corresponds to the father, the head of the kraal; the she-goat is the mother; the astragalus of a goat which had only one kid is the young married woman; whilst a number of small bones coming from the kids of different ages represent the boys and girls, weaned or not. The correspondence is perfect. Then there are the astragali of sheep—these represent the royal family, as sheep are more valuable and less common than goats.

The chief, and queens and their children are all represented by the various astragali of that domestic animal.

As regards wild animals, sets of different diviners vary very much. However, one will always find the duyker, the grey antelope which steals sweet potatoes in the fields at night. It represents the wizards, who are also supposed to accomplish their bad deeds when it is dark. The wild boar has many significations. It means the doctor, the medicine man who digs the earth to find his medicinal roots, as the pig when it searches the ground for food with its snout. It also means the spirits of the deceased, as wild boars are dwelling in the sacred wood where the ancestors were buried. By extension, this astragalus also means the old people who are soon to be promoted to the dignity of gods. The baboon represents the permanence of the village, because people say baboons never move from the cave where they dwell.

The leopard means rich people who feast on meat every day; whilst hyena means the counsellors, all the legion of flatterers who follow the chief and eat what he gives them, the chief himself being the lion and being represented by the phalanx of one of the toes of the king of animals.

A curious bone in the set of one of my informants was the astragalus of an impala antelope, discovered by him in the stools of a hyena—a wonderful finding, indeed. It meant the ancestor god, because the deceased forefather also had been swallowed by the earth and he reappeared to bless or to kill.

The malumbi is a special astragalus taken from a little red antelope, and plays a great part in the set as representing everything that is violent, which is spreading blood, the mysterious power of Heaven, the enemies, and occasionally white people.

Besides these astragali, there are quite a number of other bones or of various objects in the diviner's basket. Pieces of the carapace of a tortoise when falling on the favourable side represent the peace of the village, like a tortoise walking slowly and comfortably under the rays of the sun; everybody perspires agreeably.

Sea shells: The Oliva represents male attributes, military courage; whilst the Cyprea means the feminine attributes—pots, kitchen, baskets, and also pregnancy. When showing its opening, Cyprea indicates the open mouth, either laughter or cries.

Two stones of an abnormal form of the fruit of the nkanye or marula tree represent the vegetable world, trees, medicines, etc., and one always meets with two or more real black stones found in the stomach of the crocodile (which is said to swallow one each year). They represent darkness, misfortune, accident, or the contrary, according to the way they fall.

These are the principal pieces of the divinatory set. There are generally two of each kind, one male and one female. The diviner takes them in his hands, spits on them to give

them something of his spirit, and throws them to the ground on a mat, saying "Mamoo"! He looks at them intently, wanting to know what they have revealed. He then begins to explain what they say, always following the well-known rules of interpretation, though he may display a considerable amount of individual imagination in his explanation.

The astragalus bone can fall in four different ways. It can show its convex side. This is the positive position, and in that case the person indicated by the bone is on his legs, standing, living, healthy, active. If the astragalus falls in the opposite way, showing its concave face, it is the negative position, and the person represented by it is on his back, ill, powerless, dead perhaps. These are the two principal positions, corresponding to the upper face or the lower face of the bone respectively. But it can also fall and show its right side, which is slightly inflated. This means that the chest is full, the person indicated is full of anger, or courage, or hostility. He is like a cat which spits and is ready to tear; whilst the opposite side, the left side, is called "minkono," the elbows, and figures a person peacefully leaning on his elbows in a quiet mood.

The diviner knows the case which has been brought to him, and he looks to his bones on the mat to see if there is any correlation between the way they fall and the given case. If not, he will say: "The bones have not spoken; let us try again." Should they refuse "to speak," he goes to another place behind the hut, on the square, to try again, till he sees some correspondence between their disposition and the subject on which he must give advice or foretell something.

I have published and figured some of these cases in Volume II of "The Life of a South African Tribe" (1910),* the case of the sick mother, of the Sikororo battle amongst the Nkunas, the prophecy of a migration, etc., and I cannot do more here than refer to those plates and to their interpretation. If my readers care to study them, I am sure they will confess that this system of divination is marvellously clever, and quite capable of producing conviction in the mind of anybody, on one condition at least, viz., if he admits the magic principles which are at the base of the whole affair. If really "comparison is reason," if really like acts on like, then the astragalus of a goat can perfectly represent the fate of a mother, and the stone of the crocodile predict her fate.

The native is from his birth convinced of the truth of these principles, and therefore these bones are for him the most precious guide in life, the great inspirer and the great helper—his Bible, as one of them told me one day, and more than the Bible, as he added. He consults them constantly. Practically no disease is treated, no religious act performed, no travel undertaken without consultation of bones.

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* Copies of this book can be obtained from A. W. Bayly & Co., Lourenço Marques.

Yet it is easy to see that this practice is highly detrimental. It paralyses any attempt to use reason or experience in practical life. It annihilates moral conscience, as it makes reflection useless. Bones are thrown. They reveal the cause as well as the remedy of any disease or misfortune. There is no need any more to make an effort, to fight a battle, to employ energy in order to free oneself from the hardships of life. It can be safely asserted that no real progress in civilisation or morality can be obtained as long as the basket of the bone-thrower remains the Bible of the Bantu. But one can go further, and state that, however picturesque this magic conception of Nature may be, it is not only a check to progress, but it is decidedly harmful, and as long as it is still predominant it is impossible for the European ruler to govern the black race in a satisfactory manner. There is not only what I called white magic—these innumerable rites and practices which might be considered as quite innocent by a superficial observer, and as deserving only to be laughed at—there is a black magic, namely, rites performed to injure or to kill, or to attain certain aims by criminal means.

In the month of January of this year the Native Commissioner of Sibasa, Northern Transvaal, put in gaol the son of the chief, who was found guilty of having killed a man. When he inquired into the reason of the crime, he found that it had been accomplished for magic purposes. Rain was wanting, and the crop of the year compromised. An intelligent man who was a particularly good cultivator had been chosen, probably on the advice of the bones, and murdered. His head had been cut off and thrown into a mealie pit. Like acts on like. The wisdom and power of that distinguished native farmer would in this way spread all through the land, the gardens would be full of grain just the same as the gardens of that man, because rain would fall. And, indeed, rain fell—plenty of rain!

The murderer was arrested, but nobody really thought he was guilty. When the official tried to inquire into the opinion of the Ba-Venda on the subject, he received the following answer: "The chief's son is a fool. Why did he not send somebody else to kill that man?" As regards the murder itself, it was quite legitimate according to the conscience of the tribe.

I think, therefore, that my conclusion cannot be opposed: As long as the Bantu is so completely plunged in this magic conception of Nature, he cannot go ahead, because he is resting on fallacious ground; nor can he really be influenced by his white master. The European and the Bantu are living in two separate and opposite worlds of thought, and it is impossible in those circumstances to obtain any true communion of mind between them.

However, the position is not desperate, because it is bound to change. Let us remember that our fathers, though belonging to the so-called superior Aryan race, held con-

ceptions very similar to those some centuries ago, and that remnants of those magic practices are still found amongst the peasantry or the less cultivated portion of the town population. I was shown in Switzerland some years ago by a friend belonging to the medical profession the heart of a goat or of a sheep pierced by at least fifty big pins with large black heads. This object had been found in the hands of a woman at la Chaux-de-Fonds, the town of watchmakers—a very much advanced industrial centre. She had an enemy, and, in order to cause him pain, she was planting a pin in the sheep's heart from time to time, being convinced that, according to the laws of sympathetic magic, the heart of her enemy would be similarly pierced and made to suffer unbearable agony. A number of such practices are still to be found in all civilised countries.

Education, scientific training, higher moral and religious conceptions have delivered most of the Europeans from magic. The same will certainly happen to the Bantus if they submit themselves to the teaching brought to them by us, and there is no doubt that there is amongst them an ever-growing desire of obtaining instruction. They get it more and more now.

Thus, after so many years of work amongst South African natives, I do not fear to take a position which some may call unduly optimistic. The relation between the races may be difficult. It will perhaps become very strained, owing to faults which may be committed on both sides. But I trust that in the long run the Christian factor and the educational factor will bring them nearer and nearer. Though keeping apart from each other in many ways—I do not believe in intermarriages—they will be able to esteem each other and to reach a fruitful co-operation.

LABOUR CONDITIONS IN SOUTH AFRICA.

By R. A. Lehfeldt, B.A., D.Sc.,
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Presidential Address to Section F, delivered July 17, 1920.

The racial situation in South Africa is unique—no other country shows the same combination of white and black, and no other country offers, from its experience, a ready-made solution of the racial difficulties that exist there. That is not to say that the experience of other countries is to be ignored. Of course, the history of countries in which two disparate races have to live together should be studied, and lessons should be drawn from it for the guidance of those who control South African policy, but nothing like direct copying is possible.

South Africa's problem is unique, in the first place, because of the proportions between the two races. In the Southern United States there are whites and blacks, but though the blacks form a majority in certain districts, the situation as a whole is dominated by the presence of an overwhelming white nation, amongst whom the negroes are a handful of strangers. Moreover, most of the negroes are of mixed blood. In South Africa the pure-bred Kaffirs form the great majority of the population.

On the other hand, such a country as Jamaica contains a great majority of the black race, but there competition practically does not exist. The whites are a small ruling class, and the question who is to do manual labour, if it ever arose, has long since been answered. In South Africa there is a large and vigorous white population, partly immigrant, partly settled for several generations, which shows no sign of dying out; the relation between them and the blacks has not yet reached any condition of stability.

Examples might perhaps be found, if not now, at least in times past, where a similar numerical relation has occurred between two vigorous races, but there is another condition needed to make anything like a close parallel with South Africa, and that is a strong resistance to amalgamation between the two races. In South America, in particular, there are many interesting racial combinations, but there little prejudice against intermarriage seems to exist, whereas both Dutch and English, who make up the bulk of the white inhabitants of South Africa, are strongly opposed to mixture with the coloured races. That sentiment, which is not shared even by the French in their colonies, has played, and will play, an important part in the history of the country.

It is when there is a sharp barrier between the races that the special problem of the "poor whites" or "mean whites" arises. In every community there is a constant vertical diffusion between classes—children of the fortunate classes fall below the circumstances of their birth, whilst exceptional individuals from the mass of the people make their way upwards to wealth and influence. The process is a natural and healthy one, but where a colour bar exists diffusion is interrupted. The children of the superior race, who have not the brains nor the luck to maintain themselves in a superior position, are inhibited by the national sentiment from making a living by unskilled or low-grade work, as they would naturally do: they become destitute while clinging to the remains of racial pride; they create a special and embarrassing problem of poverty that does not exist in a country with a homogeneous population, nor—at least not markedly—in a country like Brazil, where intermixture takes place freely.

Nor does the problem of the poor whites stand alone, for the same conditions prevent the more intelligent members of the inferior race from rising. There are in South Africa natives whose brain power would enable them to do work of fair quality in administration, in the learned professions, and in business, but they are deprived of educational help and

are ostracised by sentiment. Indeed, in part of South Africa, natives hardly aspire to skilled manual labour; the consequence is a discontent, which grows stronger as the natives grow more conscious of the situation. I may remind you of those features in the history of South Africa which are most essential in understanding its present circumstances. The greater part of the Union has been settled by Dutch farmers, whose ideal was the patriarchal style of living. The family, practically isolated by distance from its neighbours, occupied an estate usually some ten square miles in extent, where they farmed for subsistence—that is, they grew a small quantity of corn and vegetables for their own use, and allowed their cattle to graze on the wild pasture around them, yielding meat and milk. On the rare occasions on which they needed money, they sold an ox or a cow at some far-off village.

The ideal of life, however, included the bringing up of a large family, and the land was divided equally between the children. Thus the kind of farming adopted could at most only last a few generations. It is being destroyed, not so much by any external circumstances—though immigration, growth of cities and modern improvements in agriculture and transport all help—as by the mere growth of population. There are districts where for several generations subdivision of farms has actually taken place, until the descendants, weakened by intermarriage, drag out a miserable life on plots of ground too small to yield them nourishment; in those districts there is much physical and mental degeneracy.

Mostly, however, the usual results of unequal ability show themselves. The more energetic or lucky son buys out his brother's shares in the family estate; marriage between landowners consolidates property, and in the course of half a century, perhaps, there comes to be the usual gradation of wealth and poverty. A class of small squires becomes established, and a large section of the country population becomes landless and dependent. It is not necessary to have the rule of primogeniture for this condition to arise; on the contrary, no legal or social arrangements have yet been invented that will stop it from arising out of the natural inequality of men.

I shall attempt a classification of the country population who are more or less poor. It will, of course, be rather vague, and I can offer no figures to show the extent of any class. Nothing at all satisfactory in the nature of a census exists. Statements have been made by Ministers as to the extent of the poor white problem; they appear to have been based on an inquiry through the magistrates, but the results of the inquiry have not been made public, and it seems doubtful whether it was conducted in a way to secure results of scientific value.

I should like, however, to refer to the researches of my colleague, Prof. W. M. Macmillan, who has made a first-hand investigation of conditions in many country districts, especially in Central Cape Colony. Though a single-handed inquiry is, of course, quite inadequate to a nation-wide social problem, and he has had no Governmental assistance, he has

been able to throw considerable light on the problem. The results, embodied in a course of lectures delivered in Johannesburg early in 1919, have now been made generally available by publication in book form.

Macmillan lays stress on the absence of any proper system of land leases in South Africa. The traditional farmer is a freeholder, and those who are not fortunate enough to own land for their farming often farm on metayage system—that is, they do not pay a fixed money rent, but share the produce of the farms with the owners, in certain stipulated proportions, with no security of tenure beyond the current season. Such conditions place them entirely at the mercy of the landowner, and though no doubt a good deal of neighbourly feeling exists, there is no secure tradition of fair treatment like that which has mitigated in practice the unsatisfactory features of English land tenure. The consequences are disastrous, for not only are the landless farmers kept down, but an improvement in agricultural methods is rendered almost impossible. Returning to the question of classification, we may distinguish, first, those who own some land, but too little to afford proper support for a family when cultivated according to the traditional methods. No doubt in many cases improved agricultural technique would be enough to make such persons comfortably off, and Government has done a good deal towards agricultural education. But the difficulties must not be overlooked. The country folk ordinarily are very lacking in general education, so that it is not to be expected that they should take readily to new ideas, and the customary conservatism of farmers is reinforced, in South Africa, by the uncertainty of agriculture in that country. The rewards are great in case of success, but the risks of plant and stock diseases, of hail, droughts, and so on, are far worse than in Europe, so that farming is something of a gamble.

Innovations backed by the authority of experts have occasionally, on trial, led only to loss, and though, it is true, the most conservative farmer sometimes loses his maize crop and sees his cattle perish of drought, failure on the part of the expert naturally makes the average countryman sceptical.

Next come the landless class who have to hire land from their more fortunate neighbours—called "bywoners" because they live on another man's land. The question that most urgently concerns them is that of leasehold tenure—as it is, they usually receive from two-thirds to one-third of the yield of the ground they cultivate. The proportion varies according to local custom, and according as the owner or tenant supplies stock and implements, but I understand that it is, on the whole, tending downwards, so that the position of the class is deteriorating. Such tenant farmers, holding only for one season, and liable to be sent away at the caprice of the landowner, cannot be expected to form an enterprising section of the community.

Thirdly come the agricultural labourers, but they do not, in practice, form a class distinct from the preceding one. The

bywoner works for wages when he can, and cultivates a little ground if he can, and usually does both. What his economic position is may be judged from the fact that a customary rate of wages in Cape Colony is three shillings a day—and that for employment which is seasonal and often leaves him for weeks without any wages at all. This class naturally merges into the next, namely, the destitute.

In this fourth class I mean to include those who are destitute without suffering from any actual bodily or mental disability. The poor white problem is essentially concerned with these; there is a fringe of poverty due to mental weakness, degenerate bodily features (such as blindness), to accidental disablement, to old age; but the core of the problem is the existence of a mass of persons who are fit to work, but are unable to do so for what may be summarised as social reasons. How many persons should be included it is impossible, at present, to say, but it seems that the bulk of the destitute country population do not suffer from bodily disease, except such as is brought on by want and unhygienic conditions, nor from definite mental defects. They constitute, therefore, a class who might be reclaimed and made into useful citizens by a suitable policy.

Their disability lies in the fact that they have neither any training in skilled work nor any habit of work. Their traditions are those of the easy life of a landowner, with Kaffirs to work for him, and they cling to prejudices against doing what they regard as "Kaffir work"—work which in England or America is done by white men, but which they expect to have done for them by servants—a pretension sufficiently ridiculous on the part of men who can hardly earn three shillings a day. Too much should not be made of this prejudice, however; it could no doubt be got over in time; the most serious defect is the ingrained laziness that goes with it.

The enormous disparity in wages between town and country tempts this destitute class into the towns, especially Johannesburg, where they expect to find the streets paved with gold, but where, of course, their want of skill leaves them really worse off than before. Some are absorbed into industry, but many are paupers, and many become the tools of more actively disreputable and criminal persons, especially as agents for the illicit sale of liquor to natives—a flourishing industry on the Rand. The migration is beginning to constitute a serious danger to the State.

The fifth group is that of the invalided and mentally or physically degenerate, who have to be dealt with by the same methods as in other countries. About them I do not propose to speak.

Apart from such problems of poverty as are common to all countries, the policy of the Government has hitherto been directed almost exclusively, in the case of rural distress, to alleviation by means of loans of land, stock or money. There have been numerous attempts at establishing small rural colonies, under supervision, and providing capital for the colonists to start with. The usual result of this is that a

few settlers make good, and in the end become substantial farmers, while the majority linger on for varying periods, lose all their new capital, and drift back into destitution. These colonies may be regarded as an experiment which has yielded some information, but the method is entirely wrong and the scale of the operations hopelessly inadequate. The latter point is clear, since the settlers are to be numbered by hundreds, while the poor whites of the country have been estimated officially at something like 100,000. As to the former point, the root-cause of the destitution to be met is that the traditional agriculture of the country folk is not suited to present-day conditions; to base remedial measures on it is sure to lead to failure—the poor whites do not know how to make a living except with a large piece of land. The first thing needed is to teach them new ways, and to train them to work harder than they have done. I am glad to say that the Department of Lands appears to have come round to this view as a result of this experience.

One settlement deserves special mention—that at Kakamas, on the Orange River. It was instituted by the Dutch Reformed Church, on the traditional lines, so far as its economic aspect is concerned, but the authorities of the Church, owing to the influence they exercise on the Dutch Africander population, have been able to exert a fatherly control over the settlers. The result has been favourable—the settlers have been trained in habits of industry, and the proportion of successes has been considerably greater than in the Government colonies. But the history of the settlement, which is an old one, carries a most important lesson—a new generation has grown up there, and many of the younger men are finding themselves in the very situation from which the colony rescued their parents—that is, there are too many of them to live on the area available.

It seems plain that the great majority of the destitutes cannot become successful independent farmers. They must go through the stage of working for wages, and then better their status if they are able to. Hence legislative efforts should aim at training them to be good agricultural labourers in the first place.

This, however, leads at once to the problem of the relations between whites and blacks. Wages of white farm labourers are, as we have seen, miserably low, but in the opinion of most progressive farmers they are as high as the labour is worth. Natives can be obtained in large numbers at about the same wage, and it is doubtful which makes the better workman. The natives are usually more industrious and, perhaps, more honest; the white man has more latent ability, and his hope lies in the development of that. Only quite slow improvement can be looked for, and policy must be based upon the hope of placing the children in a better position. Very little can be done at the best for the majority of the destitute whites of the present generation, but if their children can be well trained in favourable circumstances their racial superiority will show itself, and they may be able to

maintain themselves by work of a higher kind than the native can accomplish.

I say "may be able," for the prospects are far from clear in any case, and how far the Government is from grasping the needs of the situation may be judged from this: It has recently been felt that no progress could be made unless powers were obtained to segregate the hopelessly unemployable and send them to labour colonies under police supervision. A Bill was drafted, and one of its provisions empowered the Government to send such persons to labour colonies with their wives and children! Is it possible to imagine a more utterly misdirected policy than to send children to a penal colony because their fathers are wastrels?

Policy must be held to include all classes of education, and the attempts that are being made to promote general education in South Africa are creditable, especially in the Transvaal, but much more might be done, especially with regard to agricultural and industrial teaching. It is especially desirable to dispel the notion which the South African countryman holds—that he knows all that there is to be known about agriculture.

But whilst there is some improvement in this respect, the natives are not standing still. Their education, except in Cape Colony, has been shamefully neglected by the Government; but they are quick to learn, and so appreciative of education that they spend money on it themselves. And if they have not acquired much literary education yet, they get industrial training from the nature of their work, for they are called upon to do all kinds of work under the supervision of white artisans, and so get the opportunity of acquiring skill as mechanics, builders' workmen, miners, etc. Of my personal impressions of South Africa, none is more marked than the advance noticeable among the Kaffirs during the fifteen years that I have known the country. They are coming, moreover, to learn their economic importance, and one feels that it will not be possible for long to maintain the policy of repression which the former Republican Government adopted, and which has not yet been definitely modified.

We are now prepared to discuss, on broader lines, the future of a country whose population is one-fifth of European and four-fifths of Kaffir origin. The present conditions can only, as we have seen, be looked upon as transitory and unstable; we may, for the sake of clearer thinking, first make a list of the ultimate possibilities. These are (1) that the white race should continue to grow and colonise, and gradually drive the Kaffir race into other countries; (2) that the Kaffirs should advance so much as to create a situation economically impossible for the whites, gradually driving away the latter, except for a small governing class such as is found in India now; (3) that the two races should be effectively segregated in different districts of South Africa, and agree to leave each other alone there; (4) that they should mix to form a population which, while not actually homogeneous, would be divided by no insuperable colour line, but would permit of free diffusion between classes.

The first two alternatives may be ruled out. A "White South Africa" has been talked about, but as the natives show no sign of dying out—and, indeed, are increasing fast in numbers—it could only be accomplished by forcible migration of some five million natives, which would be outside all practical politics. Nor is it to be expected that the emigration of natives should come about because they could not stand the economic competition of Europeans—it is much more likely to be the other way about. But the second alternative is hardly more likely than the first. The white people already amount to a nation in numbers and self-consciousness: most of them were born in the country, and know no other: they certainly would not give up their country to the Kaffirs without armed struggles, unless, indeed, they were to find the conditions of life so difficult for several generations that the birth-rate dropped almost to zero. Such a suggestion may well seem absurd when one thinks of the vigorous Africander race of to-day.

We come then to segregation as a policy that cannot be dismissed quite so curtly. Nevertheless, to carry it out effectively would be a heroic policy beyond the power of any statesman. The natives are so thoroughly incorporated in the industries of South Africa that to exclude them and require them to live in certain districts, while the Europeans lived in others, would revolutionise the country. The work could not be carried on without them until a new population of unskilled labourers had been introduced to take their place, and this could only be done in opposition to all the immediate interests. Not only do manufacturers and farmers employ natives, but the white workmen are used to being supervisors of native labour. A segregation policy might in the end be to the collective advantage of the white working classes, but the immediate effect would almost certainly be a reduction in wages, since employment would have to be found for so many more whites. But if nearly all the voters in the country found that a segregation policy would be contrary to their personal interests, what chance has it of being carried out, however beneficial we may think its ultimate consequences would be?

A policy of segregation in a limited way—dealing with land ownership only—was inaugurated by the Government by a law passed in 1913. Certain areas are set aside in which only natives may own or lease ground, and they are forbidden to own or lease ground elsewhere. There is, of course, nothing to prevent their living elsewhere, as, *e.g.*, the mine workers do. This law is directed against certain minor evils, especially the custom of allowing natives to "squat" on farms that should be thrown open for proper cultivation by European methods. It may effect some improvements, but there is no prospect of its leading to any more thorough measure of segregation; and it is to be noted that the areas reserved for natives are scattered throughout the country, so that their formation does not constitute a step towards delimiting any compact region intended to be for white occupants only.

If, then, no strenuous attempt at segregation is to be

expected, if the two races are to live side by side indefinitely, racial mixture is, I think, inevitable. In the Transvaal, Orange Free State and Natal one is used to the contrast between European and pure-bred natives, and at first sight the boundary line seems one that there is neither risk nor desire of passing. But in the neighbourhood of Capetown (not the whole of Cape Colony) there is no pure native population, but a large proportion of half-castes—the so-called Cape coloured people. These are useful citizens, who are well liked in their own neighbourhood, and they tend, to some extent, to migrate to the other Provinces; there is nothing to keep them from intermarrying, either with Europeans or with pure-bred natives. Intermarriage may not be frequent, and it is true that sentiment amongst the natives themselves is rather against it. It takes place to some extent all the same, and the Cape coloured people form a natural bridge between the two sections of the population. The fact that they came into existence, despite the strong feeling against mixture between the North European races and the natives, shows how unlikely it is for the two races to live side by side without mixing.

The population described as "mixed and other coloured" in the Cape Province grew, between the 1904 and 1911 censuses, by 15 per cent., whilst the total population grew by $6\frac{1}{2}$ per cent. In the three northern Provinces, where the number of coloured people is still small, they grew by 40 per cent., while the total population grew by 23 per cent.

Where race mixture is frankly accepted, it comes as a corollary that the humblest-born citizen may aspire, not, perhaps, to the highest positions, but to an advance that will usually satisfy him, and the less fortunately endowed members of the superior race take up unskilled work, no doubt not willingly, but without incurring the contempt of their own people. The distinction of classes is like that, let us say, of England in the eighteenth century, not like that between conqueror and slaves. In these circumstances, the special poor white problem, due to the colour bar, does not exist.

If my forecast of racial mixture in South Africa turns out to be correct, it will, of course, not happen in our time. It would take several generations to come about, and the problems facing the country cannot be left to themselves in the hope that they will disappear. The Government and people are no less called upon to take energetic steps to deal with the abnormal destitution among a large section of the white inhabitants, as well as to provide the natives with opportunity for the reasonable progress they are capable of.

Let us glance at the statistics of population in South Africa to see what light they may throw on these distant possibilities. How thin the population is will be realised at once from the figure of 13 to the square mile, which is the average density, including all races. Clearly the country is yet to make.

But a large part of it is very poor agriculturally, having a small and uncertain rainfall. The western part is often known

as desert—the Kalahari—and the central part, known as the Karroo, though much more fully occupied, is not very different from the farming point of view: they are both suitable for grazing, but the number of sheep or cattle that can be safely carried is small, on account of the risk of drought. It may be that in time, with the suitable provision for winter feeding of animals, for deep ploughing and other new methods, the productiveness of the country will be increased, but it is a most striking fact that under the system now in vogue considerable stretches of Central South Africa are replete with inhabitants. Although there are only one or two to the square mile, not only is there no immigration, but increase in population drives some of the inhabitants to emigrate to more fertile districts in the neighbourhood. The area of the worst poverty practically coincides with the area in which population fell off between the censuses of 1904 and 1911. We thus find the Malthusian problem in an acute stage in a country far more thinly peopled than the Highlands of Scotland.

In the Union as a whole, the proportion of whites—about 20 per cent.—showed no perceptible change between 1904 and 1911, the two races increasing at just about the same rate. However, the registration of natives is not quite complete, and as oversights were probably less at the later census than at the earlier, this would make the natives appear to have a somewhat greater rate of increase than they really have. Their birth-rate is moderately high, and they are a good deal affected by disease: malaria is endemic, and the diseases that usually follow contact with Europeans are rife. Still, the native races are healthy enough to maintain themselves and progress. There was no immigration to speak of in the years immediately preceding the war. The war period was, of course, abnormal, but in view of the economic situation, and of the steady growth of nationalist feeling, it does not seem likely that any considerable emigration from England will take place in the future—not enough, that is, to affect the racial situation much. The most important statistical feature, if it turns out to be more than a temporary fluctuation, is that the white birth-rate is falling. In view of the war period, the figures must be received with caution, but they actually show a fall from above 32 in 1911 to below 28 per thousand in 1918 and 27 in 1919. A few more years should suffice to show how much importance is to be attached to these figures. The death-rate is low, and cannot be reduced much, if at all, further, so the natural increase of population is now tending to be less than formerly, and it is not supplemented by immigration. Thus there seems no prospect that South Africa will become any more "white" than it is at present. If it is to become so, it can only, I think, be by some deliberate act of policy on a heroic scale.

If complete racial mixture is to be the future of South Africa, we might look to Jamaica as an illustration of its fate. There the whites constitute a small aristocracy, and there are fifty coloured people for one white. But then the climate of South Africa is much more favourable for Europeans than that of Jamaica, so that the analogy breaks down.

Climatic considerations suggest a partition of the Union of South Africa into two regions—one to the east, which is favourable to the natives, where the European inhabitants are mostly of English descent, and one to the west more favourable to white settlement, and where at the present time the country people are nearly all of Dutch descent. The suggestion occurs to one that the one area might be developed as a plantation colony, with an English governing class, on English methods, and the other gradually converted into a purely European colony where Dutch ideals would have full scope for evolution. The idea may seem fantastic, and certainly cannot be described as belonging to practical politics: I throw it out as a suggestion for what it is worth.

Remembering, however, the immediate problem of how the white and black races in contact are to attain satisfactory economic relations with one another, I would venture to close with an aphorism—that a country will, in the end, belong to the people who do its work.

THE NITROGEN PROBLEM.*

By J. A. Wilkinson, M.A.,
Professor of Chemistry, University College, Johannesburg.

Public Lecture, delivered on the evening of July 16, 1920.

The birth of this Association, under whose ægis we meet to-night, took place in the year in which peace was restored to this land after three years of strenuous war. The development of the country up to this period had proceeded slowly, but the exploitation of the rich gold and diamond deposits gave the spur to a lively interest from without and quickened activity within for the sake of the wealth thus revealed. The heritage of the conflict in which South Africa was engaged in the opening years of this century may be stated in broad terms as the gradual acknowledgment by the community that the time had arrived for its evolution as a State and the utilisation of its resources for the benefit of its peoples. The partial consummation of this idea took place in 1910, when the four southern Provinces were welded into Union. Its scientific evolution, which this Association was founded to assist, and has indeed fostered to a remarkable degree, has hitherto seen its greatest triumphs, on the one hand, in the establishment and rapid development of facilities for the higher education of its citizens, such as obtain in the older countries of the world, and, on the other, in the foundation by the Government of scientific and technical departments devoted to specialised branches of

* Illustrated by lantern slides specially prepared by the author.

economic study. The early stages of this evolution have been marked by a steady progress, as the pages of our JOURNAL can prove, but at the commencement of any new work much labour of a routine character is unavoidable before we can place ourselves in the front line with the scientific workers in older countries, happy in the heritage of its accomplishment by those who blazed the trail before them. During this period, whilst we have been setting our house in order, great achievements have been made in science in all its branches, and I shall venture to-night to direct your attention for a brief moment to one of the greatest of these, whether viewed from the academic, commercial or national standpoint, namely, the chemical problem of the fixation of atmospheric nitrogen, the successful solution of which has already proved of the most profound significance, both during the piping times of peace and in the tempestuous struggles of the late war.

THE NITROGEN PROBLEM.

It has long been known to the farming community that in the rotation of crops it was distinctly beneficial to include a leguminous species, but the reason for this procedure was not forthcoming until the researches of Warington, and later of Winogradsky, had explained the function of the enlarged nodules found on the roots of these plants, namely, the bacterial transmission of aerial nitrogen in compound form to the soil. Again, the physiological chemist divides the foodstuffs which maintain our existence into five well-known classes, one only of these containing the element nitrogen, namely, the proteins. Further, it has been proved by numerous experiments that, in the absence of this particular class in a diet, life soon ceases, thus establishing the fact that the element nitrogen is a necessity for the maintenance of life. About the middle of last century, Liebig, Lawes, Gilbert and others proved that for the fullness of growth plants must be grown on a soil containing a sufficiency of the elements nitrogen, potassium and phosphorus in such form as to be easily assimilated by the roots. In virgin soils, such as are to be found in all new countries, these compounds exist in greater or less measure, but with cultivation the soil soon becomes exhausted and consequently unfertile. To remedy this defect with respect to the element nitrogen, the supplies of saltpetre found in Chili were utilised, and this substance proved to be excellent for the purpose. In addition to this, the residual nitrogen found in coal, which is obtained in the form of ammonia when this substance is destructively distilled, has been utilised for this purpose since the early 'nineties to an increasing extent.

These two substances, sodium nitrate and ammonium sulphate, were the only artificial nitrogenous manures available at the beginning of this century. In 1898 the late Sir William Crookes drew the attention of chemists to the fact that the available supplies of these two fertilisers were insufficient to meet the demands which would be created by the food requirements of the expanding population of the world; at the same time he drew attention to the oceans of free nitrogen present

in the atmosphere, which plants, except the one family mentioned, were incapable of using. In this connection it is worth noting that twenty million tons of free nitrogen have been estimated to exist over every square mile of the earth's surface, an amount sufficient, according to the late Sir William Ramsay, to afford plant food for over 38,000 years at the present rate of consumption. The quantities of available nitrogen from the Chili deposits and coal carbonisation were such that they would in a relatively short period of time prove insufficient to meet the demand created. On the other hand, the use of nitric acid and nitrates, particularly in the manufacture of explosives, was also increasing, thus decreasing the supply available for plant nutrition, and other sources of these compounds were, comparatively speaking, negligible.

The problem which therefore presented itself was the conversion of this atmospheric nitrogen into a form capable of transference to the soil for utilisation by growing plants, more especially wheat. This is now known as the nitrogen problem, and its solution forms one of the greatest achievements of this century. The methods by which this has been accomplished are as follows:—

1. Direct union with oxygen, forming nitric peroxide, and solution of this in water, yielding nitric acid and its salts. This is effected by the agency of the electric arc, the processes in commercial use being (a) the Birkeland-Eyde; (b) the Schönherr; (c) the Pauling.

2. Direct union with hydrogen, forming ammonia, and solution of this in aqueous solutions of acids, yielding ammonium salts, or oxidation to nitric acid, and formation of ammonium nitrate. This is effected by catalytic action at high temperatures and pressures on the pure mixed gases. The commercial process is known by the name of Professor Haber, who successfully investigated the equilibrium of the reaction.

3. Reaction with metallic carbides, forming cyanamide and carbon, the commercial process being known by the name of the first product mentioned.

4. Union with metals, forming nitrides, which are then decomposed, yielding ammonia and its salts. These processes are still in the experimental stage, the most promising being that of O. Serpek, which consists in heating bauxite with carbon to about 1,800° C. and subsequent decomposition of the aluminium nitride thus produced by steam or an aqueous solution of sodium hydroxide, yielding ammonia and alumina, which is stated to be of sufficient purity for the preparation of the metal by electrolysis.

5. Conversion into sodium cyanide by heating a mixture of soda ash and carbon with finely divided iron as catalyst to about 950° C. and passing nitrogen or air through the mass. The cyanide is lixiviated out with water and dried. It is then melted and air passed through, thus yielding cyanate, which is heated with water to obtain the bicarbonate and ammonia. This process is due to Professor J. F. Bucher and has not yet been worked on the large scale.

6. Conversion into the oxides of nitrogen by the explosion of a combustible gas with air, and absorption of these gases by water as in the first process. This is known as the Häusser, or explosion, process, and has been worked on a small scale with some success, using coke oven gas with air and exploding the mixture in stationary bombs. If employed as a method of producing power as well as nitric acid, the cost of the latter would compare more than favourably with the products obtained by the synthetic processes mentioned before, and the scheme is therefore one which invites further experiment, in spite of the great cost of the absorption plant which would be required for the very low concentration of nitric oxides obtained.

In addition to these, a large number of other processes have been proposed, but serious attempts have not been made to work them out commercially, and they are therefore for the moment, so to speak, of academic interest only. The case is otherwise with those specifically mentioned above, since the first three processes are, commercially speaking, large producers; and with regard to the last three, small plants are in operation with a view to overcoming the difficulties incident to large-scale production at a later stage. A brief account of the methods used in the above processes, the character and amounts of the products obtained and the factors needful for their successful operation may not be considered out of place here.

I a.—The Birkeland-Eyde Process (1903).

This has the merit of being the first nitrogen fixation process to meet with commercial success, having been introduced in 1903, when large works were first erected at Notodden, in Norway, power being transmitted at 10,000 volts from the Svaelgfos Power Station, three miles away, on the Tyn River, where there is an effective height of fall of about 140 feet. Air is driven at the rate of approximately 2 cubic metres (70 cubic feet) per minute through a flame disc at a temperature of 2,000° C. to 3,000° C., produced by electro-magnetic deviations of an electric arc. The electrodes are made of thick copper tubing and are water cooled. The diameter of the flame disc is between two and three yards. By this means a product is obtained containing about 1½ per cent. of nitric oxide. The gases leave the furnace at a temperature of 800° to 1,000° C. and are passed into boilers where the temperature is reduced to 150° to 200° C., the heat being utilised to raise steam, to concentrate the final products, and for other purposes. They next pass to the coolers, which consist of aluminium tubes cooled externally by cold flowing water, and thence to the oxidation tanks, which consist of vertical iron cylinders lined with acid-proof stone. Here the nitric oxide combines with the unconverted oxygen to form the peroxide. The cooled gases are then forced through a series of granite absorption towers, in which the peroxide is dissolved out by means of water, which is used in the last tower but one of the series, the weak nitric acid produced being then pumped to the top of the next tower nearer the oxidation tanks, and so on, the gas and the solvent

thus passing in opposite directions. The gases, before being finally restored to the atmosphere, are made to pass up a tower down which a weak solution of soda is passed.

The final products obtained in the absorption system are nitric acid of a concentration about 35 per cent., and in the last tower sodium or calcium nitrite and nitrate. Formerly the nitric acid obtained was neutralised by flowing on to limestone contained in granite vats, a watery solution of calcium nitrate being thus obtained, which was afterwards concentrated in vacuum evaporators to a certain strength and then poured over steam cylinders for final solidification. The salt thus produced was found to be deliquescent and the basic nitrate was then manufactured, but this also was abandoned in favour of the manufacture of concentrated nitric acid. By these means about 95 per cent. of the oxidised nitrogen passed through the system is recovered in practice. The fundamental reactions which take place are:—

(a) In the flame disc. $N_2 + O_2 \rightleftarrows 2\ NO$.

(b) After cooling the exit gases.

$$2\ NO + O_2 \overset{600^\circ C.}{\rightleftarrows} 2\ NO_2 \overset{140^\circ C}{\rightleftarrows} N_2O_4.$$

(c) Absorption by water. $2\ NO_2 + H_2O \rightleftarrows HNO_2 + HNO_3$.

(d) Subsequent oxidation. $2\ HNO_2 + O_2 = 2\ HNO_3$.

As shown in the equations, these reactions are reversible, and the dynamics of the process has been studied theoretically with useful results, by passing air into a platinum globe heated to a high temperature in an electric furnace, and after equilibrium had been attained cooling quickly by passing the gases through a capillary tube and then analysing. The concentration of nitric oxide at various temperatures was thus obtained, both by experiment and calculation, as also its rate of formation and decomposition, which afforded valuable data for the conduct of operations on the large scale. By increasing the volume of oxygen in the mixture until it was equal to that of the nitrogen, the concentration of the nitric oxide was increased, as also by decreasing the rate of flow through the heated globe, but in practice these have not been adopted generally.

I b.—The Schönherr Process (1907).

This differs from the above only in the type of furnace used, which consists of a vertical cylinder 23 feet high lined with refractory brick, inside which is an iron tube about five to six inches in diameter containing an insulated electrode at one end, the tube itself serving as the second electrode. Air is introduced into this tube with a tangential or rotary motion, and the arc which is formed between the insulated electrode and the adjacent tube is thus drawn out to a length of six to seven yards. The gases leave at the upper end at a temperature of about 2,000° C., and are cooled by a water jacket placed round the arc tube near the top, and, secondly, by being made to heat the incoming air. The furnace requires about 40,000 to 50,000 cubic feet of air per hour, and is

generally constructed for 600 to 1,000 kilowatts. Compared with the Birkeland-Eyde furnace, it is much smaller, and a larger installation is therefore required to give the same output. On the other hand, the apparatus is simple, durable and comparatively inexpensive. The further treatment of the nitrogen oxides and the final products obtained are the same as in the former process.

I c.—The Pauling Process.

In this arcs are employed, which are produced between two electrodes curved like those of the so-called horn lightning arresters, the air being blown through and along them from the parts of the electrodes which are nearest together, the minimum distance being large enough to allow of the air passing through. The preheated air current is blown over the arc in such a manner that it passes along the whole length of the electrodes, which are made of iron and are water cooled. Cooling of the exit gases is effected by passing cold air into the upper part of the flame from the side at a slower rate than the main air current, which has the effect of broadening the flame. Two arcs are contained in one furnace, and for a 400-kilowatt furnace 600 cubic metres of air are used per hour. The gases leave the furnace at a temperature of 800° C. In 1909 it was stated that 60 grams of nitric acid were produced per kilowatt hour by this process, which was first established on the large scale at Patsch, near Innsbruck, in Tyrol, and afterwards at La Roche de Rame, Hautes Alpes, France. The furnaces are simple in construction, about 3ft. by 4ft. in horizontal section and 10ft. high, and about 600 to 1,000 kilowatt capacity. The air is preheated before entering the furnace by utilising the heat of the gases leaving the furnace, and this is also utilised to concentrate the acid, which is marketed as such or may be neutralised to form salts.

I d.—The Moscicki Process.

This has been worked hitherto on a semi-commercial scale and differs from those previously mentioned in the method of obtaining the flame. Two concentric ring electrodes are used, the arc passing from one ring to another in a radial direction and being magnetically deviated as in the Birkeland-Eyde process, which causes it to revolve continuously around in the annular space between the rings, hence the designation which has been given to this, namely, the revolving flame method. It is stated to have given a yield of 60 grams nitric acid per kilowatt hour and to be well adapted for direct current operation. It has, however, now been discontinued.

In addition to the simple reactions already stated to occur when air is passed through an arc flame, there are others which militate against a complete theoretical extraction of the oxides of nitrogen produced. The gas which leaves the oxidation tanks for the absorption system consists of 98·5 to 99 per cent. of air and 1 to 1·5 per cent. of the mixed oxides of nitrogen from NO to N_2O_4, which when dissolved in water yield nitrous and nitric acids. In the absorption towers other

reactions take place—*e.g.*, the decomposition of the nitrous acid yielding nitric oxide,

$$3\,HNO_2 \rightarrow HNO_3 + 2\,NO + H_2O.$$

The NO thus produced must be reoxidised by nitric peroxide or oxygen or lost. If reoxidised it is possible that a mixture of nitric oxide and peroxide acting as N_2O_3 may be produced, which is caught by the alkali wash of the last tower yielding sodium nitrite—in fact, the salt obtained from this tower is a mixture of the nitrite and nitrate, in which the former predominates.

These are processes depend commercially on a cheap and abundant supply of electric energy, since only 3 to 4 per cent. of the electric energy is used in effecting the union of the nitrogen with the oxygen; also, owing to the low concentration of NO, the oxidation and absorption systems must be large and therefore costly. The total cost of electrical energy per kilowatt year at Svaelgfos and Notodden is the smallest in the world, being about thirteen to fourteen shillings, as compared with pounds in this country.

II.—The Haber Process (1910-13).

The reaction of nitrogen with hydrogen to form ammonia gas has been known for a long time, as also the fact that the amount of ammonia thus formed is very small. Nernst and Jost in 1907 examined this reaction, using a pressure of 50 atmospheres, and at a temperature of 700° C., with manganese as a catalyst, obtained a concentration of less than 1 per cent. Haber and le Rossignol a little later studied the reaction at higher pressures, and with osmium as catalyst obtained an 8 per cent. concentration. The Badische Anilin and Soda Fabrik then took up the process, and made it a commercial success, at the same time undertaking researches to discover cheaper catalytic reagents. The nitrogen is obtained by the fractional distillation of liquid air, and the hydrogen by that of liquid water gas, freed from carbon dioxide before liquefaction. Very little has been published regarding this process other than the scientific researches of Haber and le Rossignol, which showed that the most favourable working conditions were a pressure of between 100 to 200 atmospheres and a temperature of about 500° C. This gives on the large scale a 5 to 6 per cent. concentration for one passage of the gases. From a chemical engineering point of view, such conditions were abnormally severe, more especially when dealing with a gas such as hydrogen. That they have, however, been successfully overcome is now a matter of common knowledge.

On leaving the furnace where the conversion takes place, the mixed nitrogen, hydrogen and ammonia are passed into a refrigerating or absorption system, where the ammonia is liquefied or absorbed, the residual gases being returned to the system. The catalyst in commercial use is believed to be a specially prepared form of iron containing a minute quantity of potash. It is very easily poisoned, and must therefore be

carefully prepared and protected, which necessitates the purification, in the first instance, of the gases used. The first cost and maintenance of the plant used is large, and the preparation and purification of the gases, especially hydrogen, are also costly items, but, in spite of these, ammonia can be produced at a cheaper rate by this process than in any other way. The ammonia obtained may be marketed as such or treated with acids to form salts or oxidised by means of air to form nitric acid and then ammonium nitrate.

III.—The Cyanamide Process.

In 1894 calcium carbide was produced on the large scale by the process discovered independently by Moissan and Wilson. In the following year Frank and Caro, in attempting to prepare potassium cyanide for gold extraction by the Macarthur-Forrest process, passed nitrogen over barium carbide mixed with soda heated to 700° C. to 800° C., and found that about 30 per cent. of barium cyanide was formed and, in addition, 45 per cent. of barium cyanamide. When the price of cyanide fell owing to the Boer War, they used the cheaper calcium compound, and observed that cyanamide alone was formed. This substance, when treated with water, yielded ammonia, and after some preliminary trials quickly found extensive use as a fertiliser under the name nitrolime or lime nitrogen. At first, however, ammonium sulphate was prepared from it by placing it on trays in a tower up which steam was passed, the ammonia set free being subsequently dissolved in sulphuric acid. At high pressures this reaction with steam is almost quantitative, and is stated to give a 95 per cent. efficiency on the large scale.

The raw materials used in this process are lime, coke and nitrogen—substances which can be obtained in abundance and plenty. This, coupled with the fact that the raw product can be used directly as a fertiliser, and also that the power requirements are small, has made this the most popular form of nitrogen fixation, large factories being established in France, United States of America, Canada, Italy, Scandinavia and Japan, as well as in Germany. The nitrogen is now almost universally obtained by distilling liquid air according to the inventions of Claude and Linde, based on the differences of the boiling points of nitrogen $-196°$ C., air $-194°$ C., and oxygen $-183°$ C. The nitrogen so obtained is guaranteed not to contain more than 0·4 per cent. oxygen, and this small amount has caused no difficulty in practical working. It may be mentioned also that this method of obtaining on the large scale the gases of the atmosphere in liquid form and separating their constituents by fractionation is also one of the notable achievements of this century, based primarily on the researches of Professor Andrews on carbon dioxide in 1869, which first provided the key for the solution of the problem. He proved that all gases must be reduced in temperature below a certain point, known as the critical temperature, and when this was done pressure alone would serve to bring about the change to the liquid state. As a result of this discovery all known gases were reduced to liquids on a laboratory scale.

the last being helium, which was liquefied in 1908 by Professor Kamerlingh Onnes at the University of Leyden. Linde and Claude worked out the problem of their large scale manufacture, and so provided a most convenient and suitable method for procuring the necessary nitrogen from the atmosphere. What this means will be realised from the fact that at Niagara 2,000,000 cubic feet of nitrogen are required and obtained per day. Lime is prepared by the usual method of burning limestone in kilns, mechanical arrangements of the most modern type being installed for charging, discharging and grinding to ensure economical working.

Coke is manufactured from coal, the gaseous distillate being also utilised in the lime kilns, or, if the old copper method of obtaining nitrogen from the air be in use, in the reduction of the oxide formed. The lime and coke are then burnt in large electric furnaces of 10 to 20 tons capacity, working with a low voltage and high amperage to form a high-grade calcium carbide, which is tapped from the furnaces at regular intervals into trays and allowed to cool in a current of air. The material, containing about 80 per cent. pure carbide, is then ground to a fine powder in a gas-tight apparatus filled with nitrogen, an operation otherwise not unattended with danger owing to the explosive power of carbide dust, and is then placed in the cyanamide ovens of one to two tons capacity, heated electrically, and nitrogen passed in. Great care has to be exercised in this operation, since the reaction is reversible and strongly exothermic, which necessitates but little electric energy to keep the temperature up to 800° C. to 1,000° C. required. After 30 to 40 hours the hard cake of cyanamide is removed, cooled, and then ground to a fine powder in an atmosphere of nitrogen in rock-breaking machines.

To prepare it as a fertiliser, it is partly slaked to ensure decomposition of any carbide which has been left undecomposed, then stored in silos until ready for packing and transportation In addition to its use as a direct plant food, cyanamide is also used for case hardening iron goods, as a source of ammonia, and, when heated with a flux such as soda or common salt, for the preparation of crude cyanide. In the production of ammonia the reaction is carried out in steel autoclaves of 1,000 cubic feet capacity almost filled with water or alkali solution, the cyanamide being run in as a fine powder with vigorous stirring, after which superheated steam is admitted up to four atmospheres pressure. Since the reaction itself is exothermic, the evolution of ammonia soon commences, and the steam ammonia mixture given off is rectified, yielding an aqueous solution of ammonia of great purity.

Although the reaction between calcium carbide and nitrogen appears simple when written down as an ordinary chemical equation, $CaC_2 + N_2 \rightarrow N.Ca.CN. + C$, several investigators, including Professor Haber, have attempted to determine the conditions of equilibrium at varying temperatures and pressures without success. Pure carbide does not react, according to Moissan, with nitrogen, whereas the

technical operation proceeds smoothly, the impurities therefore acting catalytically. Calcium chloride has proved to be a most efficient catalyst, the reaction velocity being markedly increased and the temperature lowered to 700° C.

As has already been stated, the substances prepared and commercially marketed by the above three synthetic processes were, in the first instance, intended to supplement the yield of nitrogenous fertilisers, the sodium nitrate obtained from the Chili fields and the ammonium sulphate, which was won as a by-product when coal was carbonised in gas, shale, iron and coke oven works and in the manufacture of producer gas. The outbreak of the European War in 1914, however, necessitated the use of an enormous quantity of explosives, in which nitrogen products became of overwhelming importance, chiefly in the form of nitric acid, for the preparation of nitro-cellulose and nitro-aromatic derivatives, such as tri-nitro-toluene, lyddite, tetra-nitro-aniline, nitro-naphthalene, etc., and, in the later stages of the war, ammonium nitrate, which was the chief ingredient of the ammonal used by the Allies and donarit used by the enemy.

In its first stages the Allies, owing to command of the sea, were able to satisfy their requirements by direct importation from Chili, but this was denied to the Germans, who were therefore compelled to rely solely upon synthetic nitrogen. The commercial realisation of the Haber process took place in 1913, and it is noteworthy in this connection that German capital which had been invested in the Schönherr process was withdrawn at this period, probably owing to their faith in the new process, a faith which, as the sequel will show, was not misplaced. The production of ammonia alone, however, would have been of little assistance from the military point of view, since the nitrogen was required in the form of concentrated nitric acid. This substance could be, and was, obtained in small quantity from the Norwegian arc process factories, but concurrently with the investigations of Professor Haber into the ammonia reaction, Professor Ostwald undertook a study of the oxidation of ammonia by means of air in the presence of catalysts. That this proved successful is now only too well known, since the commercial realisation of the Haber-Ostwald ammonia oxidation processes enabled Germany to prolong the war to an extent which would otherwise have been, practically speaking, impossible, since this material is easily by far the most important munition of modern warfare.

It will be seen, therefore, that these processes have a significance and value as great in times of war as in those of peace, and owing to this fact have already attained an importance of a truly national character, in that the Governments of the United Kingdom and the United States appointed strong Commissions to investigate the problem and formulate such measures as were necessary to safeguard the nation, both in peace and war, and render it self-supporting in this regard in the same manner in which Germany had accomplished this before war was declared. The increased output of these processes under the stress of war is shown in the following

table, which was prepared by the English Commission, known as the Nitrogen Products Committee:—

PRODUCTION IN METRIC TONS.

	1913.	1914.	1915.	1916.	1917.
Norwegian Arc. Processes Ca and Ammonium Nitrates	80,034	87,135	65,068	105,640	99,499
Haber Process (in terms of Ammonium Sulphate) ...	(30,000)	(60,000)	(150,000)	(300,000)	(500,000)
Cyanamide	(156,944)	(194,726)	(771,155)	(981,500)	—?—

The figures given in brackets indicate the estimated productive capacity. The Haber process has not yet been installed outside Germany. In addition to this, Germany possesses large by-product ammonia and cyanamide plants. The intensive utilisation of these factories enabled that country to provide both the fertiliser for the wheat crops as well as the nitric acid for the unprecedented amounts of explosives which were used in the four and a half years of uninterrupted warfare.

The rapid development of these synthetic processes when compared with existing nitrogen industries is shown in the following table given by the Committee in terms of fixed nitrogen:—

	1914. M. Tons.	%	1918. M. Tons.	%
Chili Nitrate	418,000	53	465,000	41·4
By-Product Ammonia ...	288,000	36·6	340,000	30·3
		89·6		71·7
Arc Processes	10,000	1·3	27,000	2·4
Haber Process	12,000	1·5	100,000	8·6
Cyanamide Process ...	60,000	7·6	190,000	17·0
		10·4		28·3

The costs of production (Table A) have also been worked out under English conditions, and are interesting as showing that the Haber process compares favourably in this respect with all other existing processes; at the same time, owing to the purity of the ammonia produced, it is particularly adapted to the preparation of nitric acid or ammonium nitrate.

The research and experimental work done by the British Government during the war was undertaken with a view to the commercial establishment of a synthetic process in England, but this had not been accomplished when the Armistice was signed in 1918. The work, however, is not to be lost to the country, as a company, called "Synthetic Ammonia and Nitrates, Limited," has just been formed to take over from the Government the plant for the manufacture of nitrogen products from air and to develop this manufacture on the commercial scale. The method to be employed is a modification of the Haber process, as improved by the results

TABLE A.—COSTS OF PRODUCTION.

COMPARISON OF PROCESSES ON BASIS OF PRE-WAR CONDITIONS IN UNITED KINGDOM.

Scale: 100,000 Metric Tons of Fixed Nitrogen as Concentrated HNO_3 per annum.

	ARC PROCESS.	AMMONIA OXIDATION PROCESS IN CONJUNCTION WITH			RETORT PROCESS (Chili Nitrate).
		CYANAMIDE PROCESS.	HABER PROCESS.	BY-PRODUCT AMMONIA	
Power Requirements K. W. years	841,000	250,000	56,000 (estimated)	8,000 (probable)	
Coal-Steam Plant tons	5,250,000	1,560,000	360,000	(very small)	
Chief Raw Materials (approximate)	Air, Water Soda-Ash for absorption towers 58,000 tons	Tons. Limestone ... ... 761,000 Anthracite ... 270,000 Coal for Lime-Kilns 100,000 Electrodes ... ... 11,000 Nitrogen 14,000,000 cubic ft. per day.	C. ft. per day. Hydrogen ... 30,000,000 Nitrogen ... 10,000,000 Coke, 115,000 tons for making hydrogen by water gas catalytic process.	Tons. Ammonia Liquor Crude (2 °/o NH_3) 7,300,000 or Concd. (25 °/o NH_3) 584,000 Fuel for Concentrating 638,000	Tons. Chili Nitrate 95 °/o ... 718,000 Sulphuric Acid 100 °/o 661,000 Pyrites 50 °/o S ... 463,000 Fuel for Retorts ... 90,000
Capital Outlay. Chemical Plant	£ 9,225,000	£ 7,403,000	£ 9,229,000	£ 4,780,000	£ 2,767,000
Steam Power ,,	8,629,000	2,452,000	574,000	—	—
Total ...	17,854,000	9,855,000	9,803,000	4,780,000	2,767,000
Production Costs	5,180,000	5,412,000	4,115,000	8,972,000	10,018,000

of the researches indicated above, and it is stated that the company intend to erect immediately a plant for the manufacture of 100 tons of 100 per cent. ammonia per day, with provision for a rapid extension to 300 tons a day, equal to 150,000, rising to 450,000, tons of sulphate per annum. With the successful establishment of such a plant, England will in future be free from the menace of being dependent on other countries for her nitrogen needs and requirements.

In examining the case for this country, it is necessary, in the first place, to study the importation of nitrogen compounds, which are shown in Table B for the last decade

Inspection of this table shows at a glance the enormous amount of sodium nitrate imported for the manufacture of nitro explosives for mining purposes, and of cyanides for the extraction of gold. If we include also the imports of manufactured explosives, it will be seen that, compared with these items, the rest are relatively insignificant, and the conclusion might therefore be drawn that, outside the mining industry, the nitrogen problem was a matter of no importance to this country. Such an inference would, however, be unjustifiable from the point of view of the expanding agricultural industries of South Africa, which in a short time will demand large supplies of nitrogenous fertilisers. The question therefore naturally arises whether it will be possible to meet such a demand and at the same time assist the explosives industries by manufacturing nitric acid within the country itself.

The only two possible sources of any consequence at present known are the coal deposits (including shales) and the nitrogen of the atmosphere. With regard to the former, as I have shown elsewhere,* according to the most reliable estimates obtainable, namely, those of the Union Government Mining Engineer, the resources of South Africa are small in extent, forming only four-fifths of 1 per cent. of the world's coal reserves, as against $2\frac{1}{2}$ per cent. in Great Britain, and at the same time it must be remembered that the quality of much of this coal is as yet unknown. At present the greater bulk of the coal mined is burnt completely to ash for the purpose of raising steam and the nitrogen is not recovered. There is one plant at Mount Ngwibi, near Vryheid, in Natal, in which coal is burnt to destruction in Mond producers to obtain its nitrogen, in the form of ammonium sulphate, the by-products not being utilised. These works have been in existence three years, and up to the end of last year produced about 8,500 short tons, so that the total production at the same rate up to the present would be approximately 10,000 short tons, or 9,080 metric tons. In addition, there are four coal gas works, but the amount of nitrogen products recovered is, practically speaking, too small to be taken into account. At the present moment, therefore, South Africa is compelled to import nitrogen for manufacturing purposes, that required for agriculture being, as far as can be judged, small in amount. In war, the country would in this respect be entirely dependent

* *Cf. Bulletin* 28, Union Dept. of Industries.

TABLE B.—VALUE OF IMPORTS OF NITROGEN COMPOUNDS INTO SOUTH AFRICA (UNION). £

	Nitrates for Manufacturing.	Sodium Cyanide.	Potassium Cyanide.	Artificial Manures.	Nitrate of Soda.	Ammonium Sulphate.	Ammonia for Ice Making.	Ammonium Carbonate.	Ammonium Nitrate.	Collodion and Gun Cotton.	Dynamite and other Blasting Compounds.	Nitric Acid.
1910	252,251	371,156	7,115	22,053	—	—	4,516	1,138	—	58,259	21,926	449
1911	176,152	429,801	5,259	25,706	—		5,081	878	—	62,923	16,222	468
1912	283,516	365,171	1,423	25,161		—	6,074	1,010	—	72,321	16,951	398
1913	235,981	395,639	1,175	—	687	4,707	4,811	928	—	60,606	17,228	295
1914	220,511	372,130	1,887	—	227	2,408	5,313	711	7,075	50,395	12,070	349
1915	112,325	501,061	524	—		788	6,259	977	11	11,813	2,712	733
1916	278,811	445,348	276	—	15	793	6,460	1,558	8,820	—	1,559	589
1917	375,908	349,993	37,337	—	—	802	8,967	1,682	118			583
1918	253,474	309,931	38,502	—	—	—	11,936*	2,424	34		828	282
1919	305,153	127,092	297	—	—	—	10,770*	2,103	32		1,565	412

*Anhydrous Ammonia.

on imported nitrate or nitric acid, as at present, except for the works mentioned above, where the ammonia recovered would require an additional and costly plant to oxidise it to nitric acid.

The other and by far greater source of nitrogen compounds is as yet untouched, but the success which has attended the installation of synthetic nitrogen processes dependent on cheap electric power naturally turns our thoughts to the only source of water power in this country of any magnitude—the beautiful Victoria Falls. The most reliable data concerning this which I have been able to obtain are those given by the recent survey undertaken by the Rhodesian Munitions Committee, which, I believe, confirms the estimate of 500,000 available B.H.P. formerly made. That such an amount of energy must remain indefinitely unutilised for the benefit of the country is difficult of belief, but, on the other hand, it should not be forgotten that, in comparison with the water power available in other countries, it is not by any means considerable in magnitude, as the following Table C compiled by the Minister of the Interior of the Canadian Government shows:—

Table C.

COUNTRY.	B.H.P. AVAILABLE.	B.H.P. DEVELOPED IN B.H.P.	B.H.P. DEVELOPED IN PER CENT.
N.S. America	28,100,000	7,000,000	24·9
Canada A.	18,803,000	1,735,000	9·2
Canada B.	8,094,000	1,725,000	21·3
Austria-Hungary	6,460,000	566,000	8·8
France	5,587,000	1,100,000	11·6
Norway	5,500,000	1,120,000	20·4
Spain	5,000,000	440,000	8·8
Sweden	4,500,000	704,000	15·6
Italy	4,000,000	976,000	24·4
Switzerland	2,000,000	511,000	25·5
Germany	1,425,000	618,100	43·4
Great Britain	963,000	80,000	8·3

Though this is not the only chemical industry contingent on water-power engineering, yet I cannot conceive of one more fundamentally important to the country or one which would confer greater benefits on the community. The sources of energy with which South Africa is endowed from a commercial point of view at the present moment are the coal reserves and the water power of the Victoria Falls. Both these are, when compared with the resources of other countries, small in magnitude, and hence, in the interests of the country, demand, from the standpoint of national economy, rational and scientific utilisation, or, in other words, conservation in the highest degree. The only other source of energy with which the country is happily endowed in large measure is the

sun, which finds its field of action also to so large an extent in the vegetable kingdom.

Plants have harnessed the sun, and are thus enabled to bring about chemical processes and reactions of the most unending variety and the most beautiful kind, compared with which the methods of the laboratory are crude and unrefined. By nourishing the plant within the soil from the boundless stores of nitrogen in the air, we shall at least in one respect effect the development of the land awaiting cultivation in this country and give a spur to the utilisation of its real values. Whether it will be possible to increase the potential of the sun's energy, and thus obtain power of the intensity which is usually associated with this word is for future investigation and research. As is well known, serious attempts to solve this problem have already been made. When it is achieved South Africa will be rich indeed.

LIST OF PAPERS READ AT THE SECTIONAL MEETINGS.

Section A.—Astronomy, Mathematics, Physics, Meteorology, Geodesy, Surveying, Engineering, Architecture and Irrigation.

WEDNESDAY, JULY 14, 1920.

1. Presidential Address on "Recent Progress in Astronomy" by H. E. Wood, M.Sc.

THURSDAY, JULY 15.

2. The effect of high temperature and altitude of Aerodrome in the taking off of Aeroplanes: P. G. Gundry, B.Sc., Ph.D.
3. A short note on Einstein's planetary equation: W. N. Roseveare, M.A.
4. Rainfall and barometric variation in Bulawayo: E. Goetz, S.J., M.A.
5. Note on a diagram showing the amount of available sunshine falling on a horizontal surface on any day of the year at a given place and showing also the sun's elevation and its time of rising and setting. J. T. Morrison, M.A., B.Sc.

Section B.—Chemistry, Geology, Metallurgy, Mineralogy and Geography.

THURSDAY, JULY 15.

1. Presidential Address on "Geology in relation to Mining" by F. P. Mennell, F.G.S., M.I.M.M.
2. Bat Guano deposits of Rhodesia: E. V. Flack.
3. Some further factors influencing the solubility of Phosphoric Oxide in mixed fertilisers containing superphosphates: E. V. Flack.
4. The geological section between Bulawayo and the Victoria Falls: H. B. Maufe, B.A.
5. Karroo rocks in the Mafungabusi, Southern Rhodesia: A. J. C. Molyneux, F.G.S.
6. On the volumetric determination of Phosphoric Oxide: B. de C. Marchand, B.A., D.Sc.

SATURDAY, JULY 17.

7. Magnesia impregnated soils: G. N. Blackshaw, O.B.E., B.Sc.
8. Note on Kimberlite from the Belgian Congo: P. A. Wagner, Ing.D., B.Sc.
9. Calibration of Gerber milk butyrometers: C. O. Williams, B.Sc.

Section C.—Botany, Bacteriology, Agriculture and Forestry.

FRIDAY, JULY 16.

1. Presidential Address on "Causes leading toward progressive evolution of the Flora of South Africa" by T. R. Sim, D.Sc.

THURSDAY, JULY 15.

2. Ericoid leaves: D. Thoday, M.A.
3. Hakea leaf: Horace A. Wager, A.R.C.S.
4. South African Fern notes: T. R. Sim, D.Sc., F.L.S.
5. The constituents of the Flora of Southern Rhodesia: F. Eyles.
6. *Hæmanthus coccinius*: A. Mennie.
7. The occurrence of "Terblanz" (*Faurea macnaughtonii*, Phill.) in Natal and Pondoland: E. P. Phillips, M.A., D.Sc.
8. A paw-paw leaf spot caused by a *Phyllosticta* sp.: P. A. van der Bijl, M.A., D.Sc.
9. Note on the i-Kowe or Natal Kafir mushroom—*Schulzeria umKowaan*, Cke. and Mass.: P. A. van eer Bijl, M.A., D.Sc.
10. Additional host plants of Loranthaceæ occurring around Durban, with concluding summary: P. A. van der Bijl, M.A., D.Sc.

SATURDAY, JULY 17.

11. Note on the Crassulaceæ found in Rhodesia: S. Schonland, M.A., Ph.D.
12. Ripening of the seed in *Gnetum gnemon* and *Gnetum Africanum*: Mary G. Thoday.
13. The distribution of accessory food factors (Vitamines) in plants: E. Marion Delf, D.Sc.
14. A preliminary note on the flora of the neighbourhood of Bethlehem, O.F.S.: E. P. Phillips, M.A., D.Sc.
15. A method of Veld estimation: A. O. D. Mogg, B.A.
16. A contribution to the Polyporeæ of the Union of South Africa: P. A. van der Bijl, M.A., D.Sc.

Section D.—Zoology, Physiology, Hygiene and Sanitary Science.

WEDNESDAY, JULY 14.

1. Presidential Address on "Some Zoological factors in the economic development of South Africa" by C. W. Mally, M.Sc.

THURSDAY, JULY 15.

2. Some parasitic Protozoa found in South Africa, III.: H. B. Fantham, M.A., D.Sc.
3. The life-history of the African sheep and cattle fluke, *Fasciola gigantica*: *Annie Porter, D.Sc., F.L.S.
4. The economic importance of a study of Nematodes: J. Sandground, B.Sc.
5. The telluric and climatic conditions causing Gallamziekte: E. R. Hartig, D.V.M.
6. Lamziekte and its treatment: Sir Arnold Theiler, K.C.M.G., and H. H. Green, D.Sc.

7. A Tachinid parasite of the honey-bee: S. H. Skaife, M.A., M.Sc.
8. Some factors in the natural control of the wattle bagworm: S. H. Skaife, M.A., M.Sc.
9. A note on *Dasychira extorta* and its Lepidopterous parasite: C. P. van der Merwe.
10. Birds and insects in Bushman folk-lore: Miss D. F. Bleek.

SATURDAY, JULY 17.

11. Observations on live snakes in captivity: Henrietta FitzSimons.
12. Snake venom and its effects: F. W. FitzSimons.
13. Some Cercariae found at Durban: F. G. Cawston, M.D.
14. Preliminary note on the toxic effect of methylene blue injected into domesticated animals: G. de Kock, M.R.C.V.S.
15. The classification of Trypanosomes: P. J. du Toit, Ph.D., D.V.M.

Section E.—Anthropology, Ethnology, Native Education, Philology and Native Sociology.

THURSDAY, JULY 15.

1. Presidential Address on "The magic conception of Nature among Bantus" by Rev. H. A. Junod.
2. The future of the native races of Southern Rhodesia: N. H. Wilson.
3. Note on older palaeolithic implements from the Umguza and Bembesi valleys: A. W. Macgregor, B.A.
4. An exhibit of stone implements from Tiger Kloof and Taungs, Cape Colony: Rev. Neville Jones.
5. Note on rock-gravings at Metsang, Bechuanaland Protectorate: A. J. C. Molyneux, F.G.S.
6. Circumcision regiments as a native chronology: Rev. W. A. Norton, M.A., B Litt.
7. Plants of Bechuanaland: Rev. W. A. Norton, M.A., B.Litt.
8. Praises of chiefs: Rev. W. A. Norton, M.A., B.Litt.
9. Place names—map: Rev. W. A. Norton, M.A., B.Litt.

SATURDAY, JULY 17.

10. Some features of the religion of the Ba-venda: Rev. H. A. Junod.
11. Cattle as a factor in Bantu economic development: Rev. J. R. L. Kingon, M.A.
12. Notes on the Boskop skull: Rev. J. R. L. Kingon, M.A.
13. Primitive speech, or the growth of a language: Rev. W. A. Crabtree, M.A.
14. Hottentot place-names: Rev. C. Pettman.
15. Notes relating to aboriginal tribes of the Eastern Province: John Hewitt, B.A.
16. On some stone implements from Strandlooper sites in the Eastern Province: Rev. P. Stapleton, S.J.
17. Map of South Africa, showing the chief native languages and dialects: Rev. G. Beyer.

Section F.—Education, History, Mental Science, Political Economy, General Sociology and Statistics.

SATURDAY, JULY 17.

1. Presidential Address on "Labour conditions in South Africa" by R. A. Lehfeldt, B.A., D.Sc.
2. Agricultural economics (cost of production of maize): R. A. Lehfeldt, B.A., D.Sc.
3. Crime and feeblemindedness: G. T. Morice, K.C., B.A.
4. Geographical method: J. Hutcheon, M.A.

THE GEOLOGICAL SECTION BETWEEN BULAWAYO AND THE VICTORIA FALLS.

By H. B. Maufe, B.A.,
Director, Geological Survey, S. Rhodesia.

With One Folding Map.

Read July 15, 1920.

The geological section exhibited has been compiled from observations made on many different occasions. It follows closely the line of railway running north-west from Bulawayo to the Victoria Falls, the chief exceptions being an extension to the south-east of the Matopo Hills and a straight line drawn across country from Inyantue to Wankie, where the railway makes a wide detour to the south-west. Also, in places where the railway makes a considerable curve to obtain grade on ascending the basalt scarp beyond Nyamandhlovu and on descending it approaching Sawmills, the section has been shortened to give the scarps their due gradient. It has been possible to draw the section to scale through the courtesy of the engineers of the Rhodesian Railways in supplying levels; and to the same source and to Mr. A. J. C. Molyneux I am indebted for information from wells and boreholes, which has served to increase materially the accuracy of the thickness of the beds. (See folding map.)

The section extends over a length of 282½ miles. The horizontal scale is 2½ miles to the inch, and the vertical scale 500 feet to the inch, thus being exaggerated over 26 times.

Three formations are encountered along the course of the section, apart from alluvia and residual soils. The oldest formation is the crystalline schists with granite intrusions and dolerite dykes; the second formation is the sedimentary beds of the Karroo system, and the youngest is the Kalahari sand.

The oldest formation appears at the surface on two portions of the section—first, on the high veld between Bulawayo and the Matopo Hills, and again between Dett and Wankie. The first portion you will pass over on your journey to the Matopo Hills. The crystalline schists consist of greenstones and the banded ironstone or quartz-magnetite rock. Both groups are strongly folded, and dip at high angles. The greenstones are metamorphosed basic igneous rocks, generally hornblende-bearing rocks such as epidiorite and amphibolite. Certain bands in them are vesicular or amygdaloidal, and other portions show well-developed pillow structure. In parts of the country, too, agglomerates and tuffs appear interbedded with them. There is little doubt that the greenstones represent in the main a succession of volcanic rocks. The hornblendic greenstones decompose to the red clay soil which you

see in and around Bulawayo. As I do not know of any outcrop of banded ironstone on the Matopo road, I will not say anything further about it.

About half-way between Bulawayo and the Dam Hotel you will pass over stretches of pale sandy loam. This is the soil overlying some metamorphosed acid igneous rocks, which are generally spoken of as felsites. In many instances they are intrusive into the greenstones and banded ironstones, and appear to be closely related to the granites.

The granite of the Matopo and the granite north-west of Bulawayo are medium-grained biotite granites containing a considerable percentage of oligoclase felspar, and have not as a rule a strongly marked gneissic banding. The Hillside mass is a small one, and exhibits many variations of composition, some of which are without quartz, the mass being spoken of as the Hillside syenite.

The crystalline rocks exposed between Dett and Wankie include massive granite, as well as strongly-banded gneissic varieties, some of which are graphitic. The pegmatites cutting these gneisses contain, in some places, large plates of mica: in others, tourmaline and traces of tinstone. The relation of these rocks to the greenstones and granites of the high veld is not known.

The rocks of Karroo age show three types of development. The oldest Karroo rocks containing *Glossopteris* are exposed around Wankie, and consist of a succession of grits, sandstones and black shales with coal. In the station yard at Wankie you will see the top of the black shale group in which the Main Coal-seam lies overlain by a thick bed of silicified fire-clay.

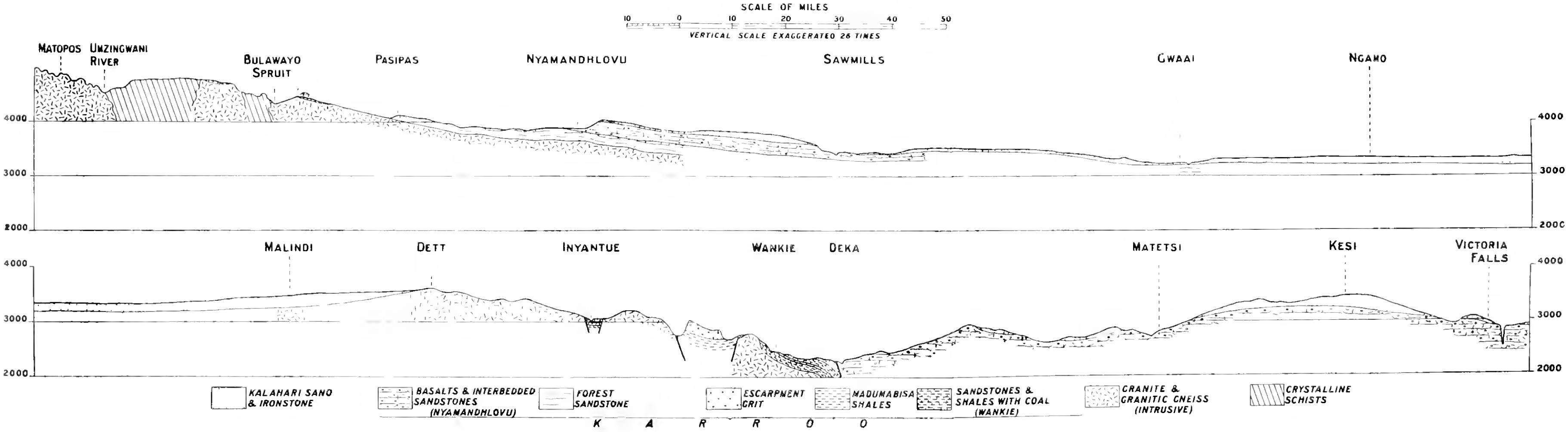
Above these sandstones and shales is about 700 feet of grey shales (Madumabisa Shales), with argillaceous limestone bands overlain by 300 to 400 feet of reddish pebbly grits. These Escarpment grits form the cappings of the high tabular hills which surround Wankie, and actually you will pass over them in the train near Lukosi before reaching Wankie.

On the high veld the Karroo rocks are of Stormberg age, as proved by reptilian remains. The succession consists of a fine white sandstone about 200 feet thick overlain by four basalt lava flows, between each of which there are in places lenticular beds of red sandstone with oblique bedding (Nyamandhlovu Sandstone). These sandstones, with basalts above and below, may be seen from the train on descending the scarp just before reaching Sawmills. An important point which this section does not prove is the relation of the high veld facies to the succession in the Wankie coalfield. The two facies come together in the Gwaai Valley, east of Malindi. I had hoped to have visited the area and settled the point before this meeting, but have not been able to do so.

Between the Deka fault and the Victoria Falls you will pass over a great thickness of basaltic lavas, which are almost certainly of the same age as the basalts of the high veld. Near Deka thin sandstones are interbedded with the basalt as on the high veld, but they have not yet been found at the

GEOLOGICAL SECTION FROM THE MATOPO HILLS TO THE VICTORIA FALLS.

[PREPARED BY H. B. MAUFE.



Victoria Falls. When you are standing at the foot of the Palm Grove, you will be able to count in the opposite wall of the gorge five successive basalt flows. The amygdaloidal top of one flow, combined with the amygdaloidal base of the succeeding flow, forms a band on the wall of the gorge which weathers differently from the more regularly jointed and more massive central portions of each flow.

In the south-western corner of the Palm Grove gorge, where the water of the Whirlpool dashes against the rocks, may be seen what I take to be a small volcanic neck filled with blocks of amygdaloidal basalt.

Before leaving the Karroo rocks, I wish to draw your attention for a moment to the two sets of trough faults—one at Inyantue and one at Lukosi—by which the Karroo rocks have been let down in long, narrow strips into the crystalline rocks. These structures are, in fact, miniature rift-valleys. The Lukosi rift-valley I have been able to trace for about 20 miles on each side of the railway. There is a third and narrower rift-valley to the south-east of the others, which passes under the Kalahari sand. It should pass beneath the railway between Malindi and Dett, but as the Kalahari sand here covers the older rocks to a great depth, I have not been able to insert it.

The faults which formed these rift-valleys are almost certainly of the same age as the Deka fault, and lend support to the suggestion made some years ago by Mr. Molyneux that the Victoria Falls basalts lie in a rift-valley, the north-western edge of which is in Northern Rhodesia.

The Kalahari beds consist chiefly of loosely-consolidated sand of a red or white colour, which, at Malindi, has been proved by a borehole to have a depth of 240 feet. At the base of the sand there is, in places, a bed of chalcedony, in which Mr. Molyneux has found gastropods and fresh-water plants, determined by Mr. R. B. Newton, F.G.S., to be of uppermost Cretaceous age. In places, too, at the base of the sand is a bed of pisolitic ironstone, which was formerly used by the natives for smelting iron.

The Victoria Falls Hotel is situated on the edge of the Kalahari sand, and at the foot of the sand-slope the chalcedony crops out. The chalcedony nodules have been used by the Bushmen for the manufacture of their stone implements, and their working sites may be found below the outcrop.

The section shows very clearly the unconformable nature of the Kalahari beds, and the gradual rise in the base of the beds from 3,000 feet at the Victoria Falls to just on 5,000 feet in the neighbourhood of Bulawayo. It also shows a pre-Kalahari valley of the Zambesi, but the tributary Matetsi seems to have cut a new course for itself not along the line of the pre-Kalahari valley. The Kalahari sand is the formation upon which the teak and mahogany forests grow, which you will pass through between the top of the scarp beyond Nyamandhlovu and Dett, and again between Fuller and Kesi.

CRIME AND FEEBLE-MINDEDNESS.

By G. T. Morice, K.C., B.A.

Read July 17, 1920.

The study of the mental deficiency called feeble-mindedness is of great importance for the promotion of social welfare. There is reason to believe that want of knowledge of this matter leads to wasted effort and expense. The subject has recently been receiving much attention in England and America. In South Africa, Dr. J. Marius Moll, of Johannesburg, has been a pioneer worker on the subject and has endeavoured to rouse public interest in it. My object in this paper is to draw attention to the bearing on criminal law of the new light on the subject.

Advancing knowledge has shown that the old broad distinction between sanity and insanity which prevailed in criminal law was insufficient. About a century ago an English Judge laid down that the insane person was one who was so totally deprived of understanding and memory as to be as ignorant of what he was doing as a wild beast. At the present day no Judge would think of defining insanity in such uncompromising terms. In fact, ever since McNaughton's case in 1843 there has been a controversy amongst English legal and medical men as to what constitutes insanity in law. We know the saying that there are no sharp distinctions in nature, and this may be expected to apply in a special manner to such a subtle and complicated entity as the human mind. Medical science is always tending to discover intermediate states between the two classes which popular language distinguishes as the sane and the insane.

In recent years much attention has been given to a class of mentally defective person known as feeble-minded or morons, whom one hesitates to place among either the sane or the insane. They are persons whose mind does not develop beyond that of a child of twelve, and though not without some intelligence are incapable of looking after themselves, and require, when grown up, supervision such as the normal person only requires in his childhood. This class of persons has been recognised in recent legislation dealing with the insane. In the Mental Disorders Act, passed in the Union in 1916, the feeble-minded person is described as one " in whose case there exists from birth or from an early age mental defectiveness not amounting to imbecility, so that he is incapable of competing on equal terms with his normal fellows or of managing himself and his affairs with ordinary prudence, and who requires care, supervision and control for his own protection and the protection of others." The chief characteristic of the feeble-minded, so far as I can make out, seems to be want of intelligence, accompanied by weakness of will, leading to the

male drifting into a life of crime or becoming a habitual drunkard, and to the female becoming the victim of seduction—the latter a lapse most calamitous for society, as feeble-mindedness is hereditary.

Although the description of the feeble-minded given above is rather vague, there can be no doubt that the medical men and others who have studied the subject have laid their hands on a real class of persons. Tests have been devised, consisting of questions and exercises, in order to ascertain whether persons belong to the feeble-minded. These are supplemented by the history of the person. The upshot has been, not only uniformity of results obtained by different investigators, but also a singular agreement between the proportion of the feeble-minded in various classes of persons in different parts of the world. Thus, in 1904, the proportion of feeble-minded children in schools in England and Wales was given at ·8 per cent., rather less than 1 in 100; and Dr. J. Marius Moll has arrived at the same figure for the Transvaal Government schools, that is, for European children in the Transvaal. This proportion of less than 1 per cent. may be taken as the proportion of feeble-minded amongst ordinary adults of the European race. On the other hand, the proportion of feeble-minded amongst convicts (*i.e.*, condemned criminals) has been found to be about 20 per cent. both in England and in the Transvaal. This means that the feeble-minded are more than twenty times as numerous amongst convicts as among ordinary persons, and the proportion increases with increased criminality as measured by previous convictions or long sentences. I am informed by Mr. Norman, the able and zealous Probationary Officer at Johannesburg, that in the case of first offenders at Johannesburg the proportion of feeble-minded was 8 to 10 per cent. In industrial schools the proportion has been found to be from 7 to 16 per cent., the proportions varying in different schools. In reformatories the figures have ranged between 8 and 25 per cent. In contrast with those comparatively low proportions, we find high figures for long-sentence prisoners. Thus, at the Central Prison, Pretoria, the proportion was 20 per cent.; on the Breakwater at Capetown, 25 per cent. feeble-minded and 10 per cent. cases on the border. In Sing Sing Prison, America, Dr. Gluch found the proportion of feeble-minded to be 28 per cent. In homes for fallen women and amongst arrested prostitutes the proportion of feeble-minded is enormous. Dr. Dunstan found it to be 90 per cent. at the Home at Irene, near Pretoria, and figures from other parts of the world make this proportion quite credible. The high proportion of feeble-minded is not confined to criminals. In the case of an Unemployment and Relief Board, the proportion of feeble-minded amongst those to be relieved was found to be 21 per cent.

It is clear from these figures that the question of feeble-mindedness is of essential importance in dealing with criminals. The credit of discovering this is due to the late Dr. Goring, an English prison doctor, who, instead of propounding a high-sounding theory about the criminal, like

Lombrosa, followed the typical English method of observing and recording facts. Dr. Mercier, in his book on "Crime and Criminals," published in 1918, somewhat depreciates the value of Dr. Goring's work, and points out that his figures do not apply to criminals generally, but to a selected class, namely, those who are caught and condemned, who are presumably the poorest of criminals in mental endowment. There is something in this. But I think Dr. Mercier lays too much stress on it, and it seems to me that the high percentage of the feeble-minded amongst convicts indicates a high, though not so high, a percentage amongst criminals, convicted and unconvicted.

The question of feeble-mindedness has to be considered in connection, first, with the trial, and, secondly, with the after-trial treatment of criminals. In regard to the trial of criminals, it is difficult to suggest any reform. It is true that in the Mental Disorders Act of 1916 feeble-mindedness may be said to be treated as a form of insanity. But mere insanity is not a defence in criminal law. The crime must be the result of insanity. In my opinion, the feeble-mindedness of a person does not free him from criminal responsibility. It cannot be said that the feeble-minded person does not understand the nature of the criminal act which he commits, or does not know that it is wrong, or that he suffers from delusions or acts under an irresistible impulse; and those are some of the tests that are applied when the defence of insanity is made.

It is quite true that in criminal law a child up to seven years old is regarded as incapable of criminal intention, and that from seven to fourteen years he is presumed to be incapable of criminal intention, or, in other words, it must be proved that he knew the act was wrong. Thus the law might take the position that the feeble-minded prisoner, having the mentality of a child of not more than twelve years old, must be presumed to be incapable of criminal intention. But though this position is logical, I do not think it would be satisfactory in practice.

Thus it would seem that the verdict in the case of the feeble-minded who has committed a crime must continue to be one of guilty. But feeble-mindedness should be looked upon as lessening the responsibility of the prisoner, as, in fact, intoxication is looked on at present. Where it is proved, as it ought to be in the case of the prisoners who have already been inmates of a prison, the sentence should be confinement in an institution for the feeble-minded.

The after-trial treatment of a feeble-minded criminal should undoubtedly be different from that of the normal criminal. It is doubtful whether the severer forms of punishment, such as whipping, spare diet, solitary confinement, serve any good purpose in the case of the feeble-minded. Moreover, release from prison on the termination of a sentence for a fixed period will in ordinary circumstances lead to a relapse into crime. Separate places of confinement for the feeble-minded are required, and special treatment. Such places of confinement would involve an initial expense,

but in the long run they might be found to be economical. The feeble-minded are, I understand, easier to manage than normal criminals, and would thus require less supervision, and probably more work could be got out of them.

In the recently published Report of the Director of Prisons, he mentions that arrangements had been made for all inmates of reformatories and all persons declared to be habitual criminals to be examined by a psychiatrist (expert in mental diseases). "Unfortunately," he adds, "the shortage of doctors at the mental asylums prevented these inspections being carried out before the end of the year, but I hope that these will be possible next year." "The results of these inspections," he says, "should be of great assistance to the administration, as undoubtedly there is an appreciable proportion whose mental condition is below par, and who are not only unsuited to the usual routine, but retard the progress of the normal inmate."

The Report only extended to the end of 1918, but I am afraid the next year of which the Director speaks has gone past without the inspections being completed, and, so far as I know, they have not yet been completed.

Further, the Director probably only refers to European inmates of reformatories and European habitual criminals. Now, it must be realised that these form only a small proportion of the convicted criminals in the Union. The native population of the Union is some five times as large as the European population, and among the prison population is found a still larger proportion of natives. Thus in 1918 the daily average of persons in custody was 15,067·6, of whom 1,175 were Europeans and 13,550 were natives and coloured, the Europeans thus being in a proportion of about 1 to 12 natives and coloured persons. The fact of the great majority of convicts being natives greatly increases the difficulty of the problem of feeble-mindedness in this country. There can be no doubt that feeble-mindedness is to be found amongst native and coloured convicts. But how is it to be detected? The tests applied in the case of Europeans are unsuitable, and satisfactory tests have not yet been discovered. The great difficulty is to find persons who understand the native and his language and possess the special knowledge that enables them to appreciate feeble-mindedness. Here is a subject that calls loudly for research. Possibly some of our missionaries will render assistance in the matter.

In conclusion, I may refer to a point which is, perhaps, rather medical than legal. Feeble-mindedness is hereditary. In the case of the offspring of the normal person and the feeble-minded, it follows Mendel's law. It is therefore of the utmost importance that the feeble-minded should be prevented from propagation. Segregation will prevent this to some extent, but, in my opinion, any law dealing with the subject should authorise sterilisation, subject to due precautions.

ERICOID LEAVES.

By D. THODAY, M.A. (Cantab.),
Professor of Botany, University of Capetown.

(*Abstract.*)

Read July 15, 1920.

A striking feature of the Maquis of the south-west region of Cape Colony is the large number of species with ericoid leaves. These are characterised by a groove, either on the upper or lower side, the stomata being confined to the epidermis lining the groove, which usually bears numerous hairs. In contrast with the Maquis, the flora of the Karroo, if one may judge from observations at Matjesfontein and Prince Albert Road, lacks such plants almost entirely.

A feature of these plants which apparently has not hitherto been noticed is that the grooves vary in the width of their opening with changes in the conditions. If leaves are allowed to dry up, they close their grooves, in many cases completely. Even under natural conditions, during drought the leaves of various species of Erica, of *Passerina filiformis*, of Stilbe sp., have been found quite or nearly closed on plants in specially dry situations. Under experimental conditions these species close their grooves when left to transpire without water, and open them again when supplied with water in a moist atmosphere. Some species of Erica, especially *E. Plukenetii*, also raise and approximate their leaves as they lose water, and spread them again as their water content increases.

THE DISTRIBUTION OF ACCESSORY FOOD FACTORS (VITAMINES) IN PLANTS.

By E. MARION DELF, D.Sc., F.L.S.,

Resident Lecturer in Botany, Westfield College, University of London; Temporary Lecturer in Botany in the University of Capetown; late Yarrow Research Fellow of Girton College, Cambridge; and Temporary Research Assistant in the Lister Institute of Preventive Medicine.

Read July 17, 1920.

Twenty years ago, when the rate of increase of the human race led certain scientists to predict a total insufficiency of the world's food supplies in the near future, Berthellot, a great French chemist, foretold that bread, meat and vegetables would soon be replaced by food tabloids, a dinner menu, for instance, reading :—

Small tablet nitrogenous matter.
Pastilles fatty matter.
A little sugar.
Seasoning.

It was indeed, until recently, a firmly established idea that the necessary elements of a perfect diet could be obtained from chemically pure carbohydrates, proteins and fats, with a few mineral salts. In 1912 Hopkins found, when breeding rats on an artificial diet of this kind, that the more perfectly purified the constituents of the diet, the less were they able to support life. Young rats ceased altogether to grow and older animals grew thin and finally died when kept altogether upon chemically pure foods, whereas the addition of minute amounts of fresh milk caused an immediate improvement and an increase in body weight altogether out of proportion to the increase of the food intake of the animals. We now know that the addition of a small amount of butter fat or of fresh green food would have had a similar effect, and it is abundantly clear that, in addition to the recognised foods, small amounts of other unidentified substances are necessary to health and are present in fresh natural foods. These substances are known as vitamines or as accessory food factors; they are unstable under chemical treatment and can be detected at present only by biological tests. They have been the subject of much research in England and America, especially since the increase of deficiency diseases in Europe owing to improper and restricted diets under war conditions.

All the evidence points to the plant as the ultimate source of these accessory food factors. Their distribution in the plant world may be roughly summarised as follows :—

1. THE ANTI-NEURITIC VITAMINE (usually identified as the water soluble growth factor).

(a) *Seeds of Plants.*—In pulses distributed throughout the embryo, in cereals found in the embryo, and also in the aleurone layer.

(b) *Yeast Cells.*—Preparations of dried or autolysed yeasts are also rich in this vitamine. During the war, yeast cake was extensively used for the treatment of beriberi, the specific form of disease resulting from a lack of this vitamine. It is possible that other edible fungi, such as truffles or mushrooms, might be found to possess the same properties, but these have not been tested.

2. THE ANTI-RACHITIC OR FAT SOLUBLE GROWTH FACTOR.

This is present in milk and butter fat as well as in certain other animal fats and fish oils. The only vegetable oil which has any appreciable value in this respect appears to be the oil of peanuts (Arachis). It is also known to be present in a variety of green leaves, such as lucerne, grasses and cabbage; but the result of recent experiments (as yet unpublished) prove that the etiolated inner white leaves of an ordinary green cabbage contain no growth-promoting properties. Fish oils, such as cod-liver and whale oils, are especially rich in the fat soluble vitamine, and it seems probable that the marine Algæ on which these animals largely feed may provide the source of the vitamines in these products.

At the present time there is an unparalleled shortage of the fat soluble accessory food factor in the civilised world, especially in Central Europe, where this deficiency is the cause of some of the terrible war diseases of these war-stricken areas. Permanent improvement in these districts can only be expected when either pasturage can be found for cattle or crops can be grown for human consumption, but temporary relief could be afforded by the much greater use of fish oils, since these are usually cheaper to obtain than the relatively expensive animal fats.

3. THE ANTI-SCORBUTIC VITAMINE.

There are two principal sources of this accessory food factor, to which a third may now be added as the result of recent research.

(a) *Vegetables.*—Many vegetables possess anti-scorbutic properties, especially in the fresh raw state. It has been possible to grade vegetables roughly in order of their anti-scorbutic value, and of all known vegetables, green cabbages appear to be the most powerful in this respect. Many storage organs, such as potato tubers, carrots and turnips, have also considerable value, and there is some evidence which suggests that their value is greater in the young than in the old condition, and when freshly gathered rather than after prolonged storage. French beans and beetroot have much less value than the preceding, as may be seen from Table I.

There is a definite and considerable loss in anti-scorbutic value when these vegetables are cooked, especially in water to

which soda has been added. In the latter case there is probably little, if any, anti-scorbutic value left.

(b) *Fruits*.—Various fruit juices have been quantitatively tested, and of these oranges and lemons are by far the best. A young guinea-pig receives a perfect diet if given oats, bran, superheated milk *ad libitum*, and orange juice to the small extent of 1·5 c.c. daily. On this diet a reduction of the orange-juice ration to 0·75 c.c. daily causes the onset of scurvy, and the minimum protective value of the juice may therefore be taken as about 1 c.c. daily. Lemon juice (*Citrus medica* var. *acida*) gives a similar result; but with lime juice (*Citrus medica* var. *limonum*) a ration of 10 c.c. (a higher ration could hardly be tolerated) is scarcely sufficient to protect from scurvy. This result has been obtained with many different samples of lime juice, both freshly squeezed and preserved in different ways. A number of confirmatory experiments were carried out at the Lister Institute by Miss E. M. Hume on monkeys which had been previously kept for some weeks in the laboratory in perfect health on a normal diet. During the experimental period a similar diet was given, but the only anti-scorbutic which was supplied was a measured ration of lime or lemon juice prepared and administered in the same way. In each case a much larger ration of lime juice was needed to give protection from scurvy. In one case the lime-juice ration of an animal which developed severe scurvy on a ration of 5 c.c. of the juice daily was, when nearly at the point of death, changed to 5 c.c. lemon juice of the same age as the lime juice. The effect was almost immediate in reducing the severity of the symptoms, whilst in the course of two or three weeks the animal was completely cured. This case of contrast between the effect of lime and lemon juice is the more striking since there is practically no difference in the chemical composition of the two juices.

Amongst other fruit juices, raspberry and tomato juices may be mentioned as giving good protective results. A variety of dried fruits have also been tested, and these retain their anti-scorbutic properties to a slight extent.

(c) *Germinating Seeds*.—In 1912 a Swedish investigator, Holst, proved that whilst dry seeds of various kinds have practically no anti-scorbutic value, when germinated for one to three days they possess considerable value in this respect. These results have been confirmed and extended in more recent experiments at the Lister Institute. The seeds of peas and lentils were soaked at laboratory temperatures for about twelve hours, and placed in a funnel to germinate covered with damp cotton wool. In two days (at about 60° F.) the radicles had grown to about 1 cm. in length, and in this condition they were used as the sole source of anti-scorbutic in the diet of experimental animals. In the case of young guinea-pigs, a daily ration of 2·5 gms. of these germinated peas or lentils was found to give adequate protection from scurvy. This may be compared with the corresponding ration of 1 to 1·5 gms. of fresh green cabbage leaf.

which was found to be the corresponding minimum protective ration under similar experimental conditions.

This result was published in a preliminary report in the *Army Medical Journal* in 1918. In the following year, cases of scurvy in prisoners of war in the East were actually cured by introducing into the diet a ration of lightly-boiled germinating beans. The importance of this result to communities cut off from supplies of fresh food is sufficiently obvious. In this connection, it is of interest to find that in parts of China it is a common custom to germinate beans before eating them, and I have been told that in parts of Africa the Kaffirs frequently germinate the corn for their own consumption. This would be of especial value in the winter months, when for long periods no fresh food would be available. It is doubtful how far the germination of corn in the production of beers makes the drink of any anti-scorbutic value. The commercial beers of the West have been tested, and found to be worthless in this respect, but this may be at any rate partly due to the high temperatures employed in the drying of the malted grain.

Summary and General Conclusions.

The accessory food factors or vitamines are widely distributed in the plant world, and are associated with definite organs of the plant body.

Seeds possess the water soluble or anti-neuritic accessory factor, but less richly than animal eggs. The embryo of all seeds investigated and the germ of cereals contain it, but the endosperm is probably lacking or nearly lacking in this respect. Vegetable oils have not been found to contain this vitamine, with the exception of the peanut (Arachis). No seeds in the dry condition have been found to contain anti-scorbutic properties.

Green leaves possess both anti-scorbutic and fat soluble (or anti-rachitic) vitamines in considerable amount. The former is a relatively unstable, and the latter a relatively stable, substance. Green leaves probably form the cheapest source of the fat soluble vitamine. The etiolated leaves of the white "heart" of a cabbage possess anti-scorbutic, but no growth-promoting properties. It seems probable, therefore, that the production of this vitamine is connected with photosynthesis in the green leaf.

Storage organs (other than seeds) contain chiefly the anti-scorbutic accessory factor, but to a less extent than either fresh fruit or fresh green vegetables. Since, however, they are easily grown and widely eaten, they are important in the prevention of scurvy.

Succulent fruits contain the anti-scorbutic vitamine even before ripening is complete. In this case the anti-scorbutic vitamine appears to be more stable than it is in the case of vegetables. The experimental evidence suggests that this is not directly due to the acidity of the juice, but it may perhaps be due to the fact that the vitamine appears to be here of the nature of a reserve product.

Germinating seeds have considerable anti-scorbutic value even before the appearance of any green leaves. They have also growth-promoting properties. In this case the vitamines seem to have been produced as the result of enzyme activity in the germinating seed.

Vitamines may thus be produced either in connection with photosynthesis or in connection with the deposition of reserves. In the latter case, the anti-scorbutic vitamine is found in the living turgid cells of underground storage organs or of succulent fruits, while the anti-neuritic vitamine is found in the much drier dormant cells of the resting embryo. Yeast is known to be rich in the anti-neuritic vitamine, but other fungi have not yet been tested.

TABLE I.—DISTRIBUTION OF VITAMINES IN VEGETABLES AND OTHER FOODS.

	Water Soluble or Anti-neuritic Vitamine.	Fat Soluble or Anti-rachitic Vitamine.	Anti-scorbutic Vitamine.
Wheat Embryo	+ + +	+ +	0
Endosperm	0	0	0
Bran	+	+	0
Peas, Beans and Lentils (soaked)	+	+	0
,, ,, (germinated)	+	+ +	+ –
Cabbage { Green	+	+ +	+ + +
Cabbage { White "Heart"	+	0	+ +
Carrots (fresh)	+	+	+
Runner Beans	?	+	+
Swede Juice	0	0	+ +
Orange and Lemon Juice ..	0	0	+ + +
Lime Juice	0	0	+ or less
Tomato	0	0	+ +
Yeast	+ + +	0	0
Milk (fresh)	+	+	+ or less
Beef Fat	0	+ +	?
Butter Fat	0	+ + +	0
Cod Liver Oil	0	+ + +	0
Peanut Oil (Arachis)	0	+	0

THE LIFE-HISTORY OF THE AFRICAN SHEEP AND CATTLE FLUKE, *FASCIOLA GIGANTICA*.

By Annie Porter, D.Sc., F.L.S., F.R.S. (S.A.),

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Read July 15, 1920.

The occurrence of liver flukes in cattle and sheep has been known for many years, especially in Europe. In South Africa fluke infection of stock was also known, but it seems to have been generally accepted that one fluke only, *Fasciola hepatica*, the common European sheep and cattle fluke, was present. Liver fluke disease, or "liver rot," becomes a disease of importance economically when its action is accelerated by such a condition as malnutrition due to droughts, or cold and wet seasons. However, the eradication of fluke disease is possible, if the means by which the animals contract the parasites is known.

It is well known that the larval stages of many flukes are passed in snails. In South Africa two problems arose, namely, whether more than one species of liver fluke occurred and what was the transmitting mollusc. During my early investigations of larval flukes found in fresh-water molluscs suspected of transmitting bilharziasis to man, I soon concluded that several groups, as well as genera and species, of Trematoda were present in two of the commoner South African molluscs, *Physopsis africana* and *Limnaea natalensis*; for example, Schistosomes, Echinostomes, Monostomes and strict Distomes were all represented. I have also examined grass and other vegetation from the banks of streams and ponds, and have found the minute encysted larval flukes thereon. By experimental work, using natural methods of infection, I have had the good fortune to elucidate, for the first time, the life-histories of several of these organisms, among them being that of the long, narrow African sheep and cattle fluke, *Fasciola gigantica*. This fluke is probably the indigenous cattle fluke of South Africa. I may mention that my results were communicated and specimens exhibited to the Veterinary Research Department at Onderstepoort in the latter part of 1919, and were demonstrated, together with the life-histories of the human bilharzial flukes and certain frog flukes, before the Witwatersrand Branch of the British Medical Association on December 18, 1919. A short account was published in the *Medical Journal of South Africa*, vol. xv, pp. 128-133, January, 1920. An exhibit was also given before the Royal Society of South Africa on March 17, 1920.

As *Fasciola gigantica* is widely distributed in South Africa, a summary of its principal features and life-history is now given.

Fasciola gigantica (Cobbold, 1856) is the large, narrow liver fluke of cattle and sheep in South Africa. It was also described under the apt name of *F. angusta* by Railliet in 1895. This fluke has been reported from certain big game, namely, giraffes, zebras and buffaloes. It has also been found once in man. The larval stages of the fluke I have found in the common pond snail, *Limnaea natalensis*, and by experimental work, using laboratory-bred rats, rabbits, guinea-pigs and sheep, I have been able to determine the entire life-history. Also, by exposing laboratory-bred, and therefore uninfected, *Limnaea natalensis* to the larvae (miracidia) issuing from the eggs of *F. gigantica*, the earliest stages in the snail have been obtained.

In 1919, Dr. Cawston described a distome cercaria from *Limnaea natalensis* in the following words: "The other encysting cercaria possesses a terminal oral and a median ventral sucker. No eyespots could be detected. The head of the cercaria is heavily pigmented, as are also the rediae in which these cercariae are produced. These rediae are three-eighths of an inch in length, and whiten the liver substance of infected snails. The cercaria itself is fully a millimetre in total length. The rediae possess a well-defined oral sucker and gut distended with particles of food. Towards the posterior end of the rediae on the left side is a poorly developed locomotor appendage." Cawston named the cercariae "*C. pigmentosa* in view of their pigmented heads." Unfortunately, the description is insufficient to enable the certain determination of the cercaria, but I believe that the organism I used, which developed into *Fasciola gigantica*, was the *C. pigmentosa* of Cawston. This may possibly be the same as *C. obscura* of Sonsino.

An outline of the structure and life-history of *Fasciola gigantica*, as I have observed it, is presented here.

When the liver of a *Limnaea natalensis* infested with this parasite is examined, it appears to be streaked with white threads, which sometimes show orange to black markings. These threads are the rediae of *F. gigantica*, the intestines of which contain orange to black contents. The rediae vary in size with the season and the particular time of reproductive activity of the fluke in the snail. The largest specimens were about 12 mm. long, but this was quite exceptional, the usual size being from 1·5 to 2 mm. long. Daughter rediae appear to be formed only towards the end of the life of the parent redia. The parent redia produces several cercariae, which are active organisms, and vary in appearance according to their degree of activity. The body of a cercaria measures about 500μ when fully extended, but when contracted it appears rounder, and may measure only 250μ. The tail is simple, and varies in length from 159μ to 200μ. The anterior sucker is fairly prominent, and the posterior one easily seen. The intestine

forks into two just above the posterior sucker. In life the body is crowded with masses of cystogenous granules contained in unicellular cystogenous glands, which cystogenous granules ("pigment" of Cawston), together with yolk, largely obscure the finer details of the organisation.

When an infected snail is isolated in water, the cercariae readily leave it, and can just be seen with the naked eye swimming actively in the water. After a time they leave the water and creep up the stems of any plant in their vicinity. Each cercaria commences to extrude the cystogenous granules from its body, and soon casts its tail. The body then contracts into a spherical mass, surrounded by a cloud of granules forming a viscid coat. These gradually condense and form a thick cyst wall, which hardens on exposure and contracts somewhat; they measure 450μ to 650μ in diameter. The encysted cercaria shows its two suckers, forked gut, genital rudiments and the remains of the cystogenous granules. The encysted cercariae on herbage by the waterside are in favourable situations for ingestion by any herbivorous animal, such as ox, sheep or buffalo. I may mention that from one infected *Limnaea natalensis* I have obtained 1,070 perfect cysts, and several hundreds are usually produced from an infected snail.

By direct experiments of feeding herbivorous animals (sheep, rabbits and guinea-pigs) and omnivorous animals (rats, mice) on green barley and cabbage contaminated with cysts of *C. pigmentosa*, I have succeeded in obtaining adult flukes corresponding with the adult Trematode, *Fasciola gigantica* of Cobbold. These adult flukes varied in size, large ones being 55 mm long and up to 9 mm. broad, while small specimens were about 20 mm. long. Sexually immature forms were also present in my experimental animals, varying from 5 mm. to 19 mm. in length and in breadth from 2 mm. to 4 mm. The sides of the body are nearly parallel, and the cephalic cone is short. The anterior sucker is distinct, about 1 mm. in diameter; the posterior sucker (acetabulum) is prominent, and in large specimens reached 1·8 mm. in diameter. The genital pore is situated just above the anterior margin of the acetabulum, and the intromittent organ often protrudes from it. The pharynx is well marked, the oesophagus short, and the numerous lateral, branching intestinal caeca are directed slightly backwards.

The reproductive system consists of two testes, placed one behind the other and much branched. Each has a vas deferens, and the vasa deferentia unite anteriorly. The ovary is relatively small and is branched. The uterus and oviduct are convoluted. Yolk glands are present and are greatly branched. The vitelline ducts are readily seen, and the transverse junction is dilated centrally into a vitelline receptacle. A large shell gland is present. The eggs are large, measuring about 175μ long and 85μ broad.

Typical experiments that I made in connection with the elucidation of the life-history of *Fasciola gigantica* may be briefly summarised. Thus, a rabbit was fed with green food contaminated with cysts from *Limnaea natalensis*. It gradually became emaciated, and died 64 days after the infective

feed. At post-mortem over 20 adult flukes were obtained from its liver, which was enlarged, had much thickened bile ducts, and showed marked disintegration of its capsule. Recent haemorrhages into the connective tissue around the terminal part of the rectum and lower part of the abdomen, together with a haemorrhagic sac between the deep and superficial muscles of the thigh, were present, and these haemorrhages contained one or more flukes.

Similar results were obtained with a guinea-pig, which died 74 days after the infective feed.

A young sheep, bred from and belonging to a stock known to be free from liver fluke, was fed with green barley contaminated with encysted cercariae from *Limnaea natalensis*, two such feeds being given. On the first occasion only a few cysts were available; on the second, about 250 cysts were administered. The animal died 143 days after the first and 119 days after the second infective feed, and 223 adult flukes were recovered from it at autopsy. Sixty-four days after the second infective feed the animal was noticed to be less active and to lie about a good deal. This behaviour continued at intervals until it died. For seven days prior to death most of its food was refused, but it ate its mash and some green barley on the day previous to death. At post-mortem the body appeared well nourished. The liver showed marked perihepatitis, was greenish in colour, with numerous blackish haemorrhages. There was slight oedema. The bile ducts were greatly thickened and fibrotic. The intestines were heavily bile-stained, and contained some flukes in the canal, which also showed many small haemorrhages. All the blood-vessels of the mesentery were engorged. A small haemorrhage beneath the skin near the anus contained one fluke. The organ most affected was the liver, from which 189 flukes were recovered. The bile ducts were blocked in some places with tangles of two or three flukes.

Similar experiments were performed, using rats and mice, with similar results. The minimum time before adult, sexually mature flukes have been obtained experimentally has been 64 days.

The eggs of *Fasciola gigantica* do not hatch readily under experimental conditions, and my experience has been that they take from 11 to 54 days before the miracidia emerge. Direct infection of laboratory-bred *Limnaea natalensis* with the miracidia of *F. gigantica* has been carried out, so that the complete developmental cycle is now demonstrated.

Fasciola gigantica is fairly widely distributed in South Africa. Thus, following on my communication to the Veterinary Research Division in 1919, the then Acting Director, Mr. D. T. Mitchell, sent to a well-known "fluke" district in the Transvaal, and it was found that sheep and oxen there were parasitised with *F. gigantica*, not *F. hepatica*, as had been thought. Similar finds were made in Swaziland. *F. gigantica* has since been reported from several Transvaal localities, and I have found it fairly commonly in the livers of cattle condemned for fluke in the Johannesburg abattoirs.

where it is almost as common as *F. hepatica*, and mixed infections of the two flukes occur. Specimens have also been obtained by me from Natal, from the Eastern Province and the Western Province of the Union of South Africa, and from cattle sent from Rhodesia.

With regard to preventive measures, the following precautions are suggested: Where *Limnaea natalensis* occurs, vegetation should be reduced to a minimum at the edges of the ponds and streams, and reeds and bulrushes should be cut back. These plants are favourite places for breeding and the food for choice for the snails, and their absence is therefore a deterrent to the spread of fluke. The Limnaea also feed greedily on the leaves of the blue water lily, on the underside of whose leaves they lay their egg masses.

Cattle and sheep should be kept from damp, marshy soil, where Limnaea is present in the water. I have found infected snails twenty feet from the edge of the water in marshy spots in Natal. Watering of stock with water that has been stored for two days is almost sure to be safe. The cercariae of *Fasciola gigantica* rarely survive more than thirty-six hours in water, and unless there are facilities, such as grass or débris on which they can encyst, they either perish or else they encyst on the sides of the storage tank, just above the level of the water. The cysts are not easily washed off when water is drawn, but can be scoured or scraped off and burned when the tank is empty. The latter precaution of burning is necessary, as the cysts remain alive for considerable periods

Some recent experiences and observations in the open have shown me that ducks are very efficient in destroying pond snails, and, in the absence of the necessary molluscs, the life cycle of the parasite fails. It is possible that the ducks may transport the eggs of the snails from one pond to another, but it seems to me that the danger therefrom is much less than that due to the presence of the snails, all kinds of which are greedily devoured by the ducks.

SOME PARASITIC PROTOZOA FOUND IN SOUTH AFRICA.—III.

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(*Abstract.*)

Read July 15, 1920.

The present communication forms a continuation of preceding ones made at Annual Meetings of the Association in 1918 and 1919, and published in this Journal, vol. XV, pp. 337-338, and vol. XVI, pp. 185-191. Preliminary accounts only are given, as the work is being continued, and it is hoped to publish fuller, illustrated accounts later, after more extended study. This record, however, contributes to our knowledge of the distribution of the parasitic Protozoa.

Attention may be drawn to two points, the finding of seasonal variation in the occurrence of Sarcosporidia, and the presence of several genera and species of Ciliata in the digestive tracts of various Ungulata.

The term "parasitic" in the title is used in a wide and general sense; some of the organisms described may prove to be saprozoites and some may be commensals.

Sarcodina.

Few additional Protozoa belonging to this class have been seen by me since my last report. On two occasions a few amœbae have been found in the colon of horses at Onderstepoort. These are probably specimens of *Amœba* (*Entamœba*) *intestinalis* mentioned by Gedoelst (1911)* as occurring normally in the intestine of the horse. The making of permanent preparations was difficult, as the infections were very scanty.

Mastigophora.

The blood of some "field-mice," *Arvicanthis pumilio*, caught in the neighbourhood of Onderstepoort, contained *Trypanosoma lewisi*. One rodent out of three had a heavy infection in its heart and internal organs.

About 400 dog-fleas, *Ctenocephalus canis*, were examined in Johannesburg for possible intestinal flagellates. Only one flea was found to be infected with *Herpetomonas ctenocephali*, and the parasitisation was slight.

Trichomonas suis was seen in the caecum of a pig in Johannesburg. Two forms were observed, one large and broad and the other relatively long and narrow, with folded membrane. Division of the narrow forms was observed.

* "Synopsis de Parasitologie."

A *Trichomonas*, probably *T. ruminantium* of Braune (1913),* was seen in the reticulum of three sheep and one ox examined in Onderstepoort and Johannesburg. The infections were slight.

A *Trichomonas* was also seen in the rectum of a Muscovy duck in Johannesburg. The duck suffered from diarrhœa.

A *Bodo* was observed in the rumen of a sheep in Johannesburg.

A *Cercomonas* was found in the reticulum of an ox in Johannesburg. Probably it is the same organism as *Cercomonas rhizoidea* recorded by Liebetanz (1910) † from the rumen of cattle, sheep and goats.

Small, ovoid flagellates, each with one relatively long flagellum, corresponding to *Oikomonas communis* of Liebetanz, have been seen occasionally in the rumen and reticulum of sheep and cattle in the Transvaal.

Small, round flagellates, apparently the *Sphæromonas communis* of Liebetanz, have been observed in the rumen and reticulum of two goats near Pretoria. This flagellate is placed by Braune in the genus *Monas*, as *M. communis*.

The very interesting and primitive organism, *Selenomastix ruminantium*, which is perhaps a Proflagellate, may be mentioned here. It was seen in the rumen and reticulum of two goats in the Transvaal.

SPOROZOA.

A *Lymphocytogregarina* was found in the lymphocytes of the blood of a freshly-killed giraffe shot in Barotseland. I have pleasure in thanking Dr. Hertig for the film.

I have received from Mr. S. H. Skaife, of Cedara, Natal, some hive-bees which he suspected to be infected with spores of *Nosema apis*. I have determined that this parasite was present and confirmed the diagnosis. Some deaths occurred among the hive-bees from this infection.

The Myxosporidia, recorded by me from various fish last year, were seen again while I was on a visit to the Cape Peninsula in February, 1920.

SARCOSPORIDIA.

While examining organs of sheep for *Sarcocystis tenella*, I have found spores of the parasite in the reticulum and cæcum, as well as in blood smears from the heart, lymphatic glands and spleen. A young multinucleate trophozoite was seen in a scraping of heart muscle of a sheep. For the loan of some of the smears mentioned I am indebted to friends and fellow-workers.

During 1919-1920, while examining fresh post-mortem material from domestic animals at the Veterinary Research Laboratory, Onderstepoort, Transvaal, occasion was taken weekly to examine scrapings and smears of heart muscle for spores of *Sarcocystis tenella*. The hearts of sheep and cattle, especially the former, were most usually available. Three to

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* Arch. f. Protistenkunde, xxxii, p. 111.
† *Ibid.*, xix, p. 19.

four animals were generally obtainable each week from the post-mortem hall. The muscle of the apex of the ventricle was found to be most convenient for examination. Sarcocysts (Miescher's tubes) were not usually seen in the smear-preparations of heart muscle, but free spores (Rainey's corpuscles) occurred. Attention was concentrated on the spore stage.

Beginning in April, 1919, it was found that the spores of *S. tenella* in the sheep were regularly seen for about four months, but apparently became very few or absent during the latter half of July. During August and September and the earlier part of October, 1919, the spores were rarely seen. During November, 1919, and onwards to May, 1920, the spores were again regularly seen, and usually found to be numerous.

A seasonal variation seemed to be indicated, the spores of *Sarcocystis tenella* appearing to be relatively few or even absent in the heart muscle of sheep during the colder months of June, July and August—which are winter months in South Africa—but showing a very slight increase in numbers during the months of September and October—which are spring and early summer months in South Africa. This was the inference drawn from the observations made during 1919. The winter of 1920 has been slightly milder, and—continuing the record of my observations up to September, 1920—the spores of *S. tenella* appear to have been rather more numerous during the winter of 1920 than during that of 1919. The animals examined were nearly all adults. These observations are not yet complete and are being continued, but the available evidence goes to show that spores of *S. tenella* in the heart muscle of sheep examined near Pretoria are less numerous in the winter and spring or early summer than in the middle and late summer.

Similar observations on the *Sarcocystis* of cattle have been commenced, and so far the results obtained appear to be somewhat different.

Seasonal variation is an example of periodicity in nature. The occurrence of such periodicity is probably much more general and of greater importance than has hitherto been suspected.

It is interesting to note the results of J. W. Scott (December, 1918),* who has been working on *S. tenella* in sheep in the Northern Hemisphere, namely, on the Laramie Plains, Wyoming, United States of America. He finds that infection is seasonal, the infections being less numerous in the winter and spring. He worked on sarcocysts, and the period of incubation after infection before sarcocysts appeared in the muscles was from four to six weeks. He states that ewes become infected year after year in successive seasons and that the life-cycle falls under seasonal control. Scott's researches are not yet complete.

INFUSORIA.

A number of Ciliata have been found in the alimentary tracts of Ungulata, especially in the rumen and reticulum of

* Journ. Parasitology (Urbana), v, p. 45.

cattle, sheep and goats, and in the cæcum and colon of horses in the Transvaal. Relatively few horses were available, and most of them had died from horse-sickness.

Isotricha was recorded last year from the rumen and reticulum of a bull. It has been seen again in the corresponding organs of sheep, cattle and goats. Apparently both the species, *I. prostoma* and *I. intestinalis*, were observed, but the latter occurred on few occasions and in small numbers.

Sheep and cattle examined in the districts of Pretoria and Johannesburg have also harboured the following Ciliata in their rumen and reticulum: *Dasytricha ruminantium*, *Diplodinium ecaudatum* and a species of *Buetschlia*. The first-named of these ciliates is placed in the genus *Isotricha*, as *I. ruminantium*, by Braune. Several varieties or formæ of *Diplodinium ecaudatum* were seen, namely, *caudatum* (with one caudal spine), *bicaudatum* and *tricaudatum*, following the nomenclature of R. G. Sharp (1914).* The *Buetschlia*, probably *B. parva*, were seen less frequently than the other ciliates mentioned. A few of these organisms reach the omasum and may occasionally be found there.

A Heterotrichous ciliate, which Braune (1913) considers to be *Entodinium bursa* Stein, has often been observed by me in the rumen and reticulum of cattle, sheep and goats. It is very easily distorted by slight change in the temperature of its environment. I regret that I have not yet been able to consult Stein's original description of the organism. The various forms of this ciliate figured by Braune have all been seen by me, as well as other forms, especially some showing various contractions at the anterior end. Other allied organisms, with spines varying in size and number, have also been observed, and may be forms of *Entodinium caudatum* Stein. These organisms are most difficult to study, and do not appear to have been adequately described or figured by previous workers. Further illustrations of these Ciliata are needed. I have been able to prepare some of these illustrations already from living material, and the observations are being continued.

Blepharocorys uncinata was recorded last year from the cæcum of a horse. It has been seen since in the cæca of most of the other horses examined, and has been found, but less frequently, in the colon. Another species, *B. valvata*, has also been seen in the cæcum and colon of the horses; it has been found more frequently than *B. uncinata* in the colon.

In the cæcum and small colon of four of the horses a few *Buetschlia postciliata* were found.

On one occasion a fresh specimen of *Triadinium caudatum* was found in the small colon of a horse at Onderstepoort.

Cycloposthium bipalmatum has been observed in the cæcum and colon of many of the horses before mentioned. The infections were poor in each case.

Regarding the remarks last year on *Balantidium coli* in pigs, it may be added that two living specimens of the parasite

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* Univ. California Publications in Zoology, xiii, p. 43.

were found, each containing erythrocytes, in a portion of the cæcum of an apparently healthy pig in Johannesburg. No ulcers were seen in the cæcum and colon of the pig.

Examination of the Ciliata in the living condition is most important, in order to obtain a correct knowledge of their delicate structures and proportions. Many of them, such as *Diplodinium* and *Entodinium*, are very susceptible to change of temperature below that of the vertebrate host. The cooling produces retraction of cilia and distortion of parts.

SPIROCHÆTÆ.

Organisms belonging to the Protistan group *Spirochætacea* have been found in the crystalline styles of the Lamellibranchs, *Mytilus crenatus* and *Tapes corrugata*, obtained at Three Anchor Bay, Capetown. In the former (*Mytilus*) the specimens of spirochætes that were measured were 60μ to 100μ in length and about 1μ in breadth, with acuminate ends. In the latter (*Tapes*) the spirochætes were 40μ to 70μ long and about 1·5μ broad, with rounded or slightly acuminate ends. Both spirochætes were of the *S. balbianii* type, showing a membrane or crest, especially those of *Tapes*, wherein the parasite usually had a few changeable or unfixed coils on its body. The *Mytilus* spirochætes, in addition to being longer and thinner, possessed more flexible bodies and were more rapid in movement than those of *Tapes*. A diffuse nucleus of chromatin rods was present in each parasite. The *Tapes* were rarely infected (1 in 15), while the *Mytilus* were somewhat more often infected (7 in 75), the molluscs being examined in March.

A small, thin spirochæte was found in the rectum of the Muscovy duck already mentioned. The organism measured 10μ to 15μ long and had pointed ends.

I would especially thank the Director and Officers of the Veterinary Research Laboratory at Onderstepoort for valuable material and facilities for work, and the Research Grant Board for a grant towards the cost of collecting some of the material for this investigation.

THE FUTURE OF THE NATIVE RACES OF SOUTHERN RHODESIA.

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(*Read July* 15, 1920.)

There appear to be three possible attitudes for a reasoning man to take towards the native question, and our thoughts on the future of the native races of Southern Rhodesia will be governed by our adopting one or other of these attitudes.

Firstly, we may accept the saying that everybody, white or black, has the right to rise to the highest point to which he is capable of rising. This was a saying endorsed a few days ago in the Legislative Council by one of our Labour members. As to the qualification of "capability of rising," I shall have something to say later. At present I only wish to point out that, if we believe that the Western European civilisation (for which we stand, and by reason of the superior claims of which we are here to-day in this territory) is in any degree worthy of our claims on its behalf, then by accepting this saying of the right to rise to the highest possible point, we must, unless we are hypocrites, imply that the native has a right to rise to the standard of that civilisation: and we must likewise accept as a desirable outcome of native development the gradual elevation of the native to the conditions of existence of the European.

Secondly, we may believe that the native in his kraal probably has a more equable and contented life than modern conditions allow most Europeans, and we may consider the ideal policy on his behalf would be to leave him untouched, to segregate him completely (not mere land ownership segregation) and leave him to work out his own salvation in peace, with a modicum of guidance from a paternal government.

Thirdly, we may honestly look upon the native as an inferior race, to be exploited to the full in the interests of the superior European race.

All three attitudes may be supported by a mass of arguments, the truth of which it is difficult to deny, but it is essential to choose between the conflicting claims, and to adopt one definitely for our guidance, the fixed point about which we must manœuvre.

The third line of reasoning (the Exploitation Theory) is not incompatible with a feeling of kindliness towards the inferior race, and an unshakable determination to see fair treatment meted out to the native. So a decent-minded man regards his horse, his dog, his ox. It appeals to many from its apparent consistency with the evolutionary theory of life as a perpetual struggle, in which biological necessity compels the strong to prey upon the weak under pain of extinction. But, as we recede from the days when the Evolution Theory was first launched upon the world,

we are less and less bound by every facile analogy founded on it. We recognise that the evolutionary laws applicable to social integrations are not entirely similar to those of the struggle of species with species. We recognise, indeed, that for one race to enslave, or systematically to exploit an inferior race, may possibly react more unfavourably upon the exploiting race than upon the exploited. After this the exploitation attitude appears merely short-sighted and selfish, and a nation adopting it as a policy would inevitably move steadily to decay.

The second line of thought, the Complete Segregation Theory, is more specious than sound. It is based on deep pessimism, and is a denial of the results of three thousand years of civilisation. It is a belief of hopeless negation, and, moreover, is put out of court by the real impossibility of carrying out any policy founded thereon. It is a chimera. To imagine that two virile races could exist side by side without any intermingling of ideas and forces is to suppose that two gases in one vessel will not mix; it is to imagine an absurdity, a thing that cannot be.

We may mention, in passing, the opposite to the Segregation Theory, namely, the Miscegenation Theory, which is believed by some to hold the secret of the future of South Africa; the theory that the eventual outcome will be neither white nor black supremacy, but one all-embracing hybrid race. This prospect appears altogether repulsive, and is, I believe, without any foundation of probability. No more need be said of it.

We thus find ourselves forced back upon the policy many will have adhered to in the first instance, namely, the gradual elevation of the native to the conditions of existence of the European. This, as I have said, must be implied in the saying that everybody, black or white, has the right to rise to the highest of which he is capable. Sir Wm. Beaumont, addressing the Natal Native Affairs Reform Association, put it thus: "The only sound native policy we can adopt is the general advancement of the natives industrially, socially, educationally, and politically, with as much freedom as is consistent with good order and government." A righteous desire to justify our presence in this territory and enlightened self-interest alike indicate that as the policy we must adopt, and assume as being carried out, when we wish to look into the future of the native races of Southern Rhodesia.

The ideal of steady development of natives along the lines of, and in a direction tending towards, European civilisation, industrial, social, and political, must not blind us to the fact that our civilisation at present rests on the undisputed supremacy of the white man.

I shall return to this point shortly.

Let us hark back a little way, and consider the saying: "Everybody, black or white, has the right to rise to the highest point of which he is capable." Now, what does the qualification, "of which he is capable," imply? Here I come to extremely disputable ground.

In the mind of the Labour member of the Legislative Council to whom I have referred, the qualification was evidently intended to cover quite a lot. Perhaps I cannot do better than quote from the debate:—

"Recently he had heard a remark that everybody, white and black, had the right to rise to the highest point he was capable of. He agreed with that principle most heartily. No trade unionist would disagree with that sentiment. The native had his limitations. . . . . . He had clearly stated that he was quite prepared to allow for men, white or black, equal opportunity to the limit of the men's ability. Those best able to judge of what the native's abilities were, were very much divided upon the subject. Broadly speaking, there were very few natives in this territory who were able to rise beyond the educational ability of a child in the third standard. He was quite willing that the natives should be developed along the lines on which they ought to develop. His belief that the native was unable to rise to the standard of the white man was the compelling factor in making him say that he fully believed that legal enactment of the colour bar would never be necessary. He did not think the position would ever arise in which the native in any numbers would come into competition with the white man; he did not think the native had the ability to rise to that point."

That is very illuminative. Put shortly, it amounts to this: Let everyone, white or black, have the fullest opportunity of development, as the black is quite incapable of developing. In other words, let a Derby winner and a cart-horse have a fair field and no favour—and devil take the hindmost. Exactly, but suppose the cart-horse should turn out to be a race-horse? I need not remind you that a Grand National winner was once bought from the shafts of a cab. Suppose the black man should surprise us by showing that he is capable of quite a lot of development? What then? I imagine that few here will agree with the quotation I have just given in its extremely low estimate of the native capacity. It would seem that it is necessary to consider the question: Of what degree of development is the native capable? Unless we form some conception of an answer to this question we may make some very startling discoveries along the road we are to travel; we may possibly find we are on the wrong road altogether—the road leading to disaster which we so earnestly desire to avoid. Let us consider, then, of what degree of development is a native capable.

Our first step brings us to a parting of the ways. We find two distinct schools of thought, holding diametrically opposed beliefs. We may call them the Schools of Racial Heredity and of Environment.

The first, the School of Racial Heredity, basing itself on the narrowest and most exclusive interpretation of the evolution theory, finds the demarcation between races so distinct as almost to make them different species. It deduces therefrom totally different sets of psychic faculties in black and white. The black races will always remain essentially inferior in brain power and all other traits to the white; the most that can be allowed is a certain degree of imitative ability. It is utterly futile to expect that African natives in a totally different stage of evolution should show any brain calibre approaching the European. This school is closely allied to the school represented by Gobineau and Nietzsche in European ethnology.

The other, the School of Environment, or Social Heredity, believes that all human races are endowed with exactly similar faculties, and that the development depends entirely on the environment. It ranks the capacity of an Australian aborigine with that of a Western European. It can see no essential differ-

ence between an Andaman Islander and a product of France of the twentieth century. One of the protagonists of this school is Jean Finot. He submits the system of skull measurement to a careful cross-examination, and finds that all the talk of dolichocephaly and brachycephaly is so much moonshine. He finds similar failure in all anthropometrical systems directed towards discovering race differences. His examination of psychic differences is not so acute, but gives, in his hands, similar results.

I cannot go the whole way with either school. Few, I imagine, will find it necessary to express their disagreement with the American who proved that a negro was not a human being at all in the following way:—

> God made man in His own image:
> Everyone knew God was not a negro:
> Therefore a negro could not be in the image of God;
> Therefore he was not a man.

I have—everyone has—known so many instances of family heredity, some little peculiarity coming out in father, son, and grandson, or, more noticeably still, skipping one generation, that I cannot believe that racial heredity counts for nothing. I cannot accept the dictum that environment or social heredity is everything.

I am inclined to feel for a blend of the two schools. If I might be permitted the simile I should liken the Racial Heredity to a stake driven into the ground, and Environment to the chain by which we are joined to the stake, and within the range of which we may roam. The stake is driven into the ground at different spots for different races, but never very far apart, say a few feet the limit of the variation. The chain is of varying lengths, from ten feet to several hundreds of feet. The point of the simile is this—that by virtue of mere heredity the various races of mankind are not far apart, but by virtue of the environment, represented by the greatly varying lengths of chain, vast differences result.

To carry my simile a step further, I should like to suppose a different set of stakes and chains for the physical, intellectual, and moral attributes of the various races.

With great diffidence I offer this as a possible explanation of the extremely diverse results achieved by advocates of Racial Heredity, and Environment, or Social Heredity. I believe if the essential separateness of the physical, intellectual, and moral attributes were accentuated and understood, and the varying degrees of influence exercised in each sphere by Racial Heredity and Environment, or Social Heredity, studied with this separateness in view, we should be very much nearer to a true science of ethnology, psycho-anthropology, and anthropo-sociology.

I shall accept my metaphor as giving a working hypothesis for the consideration of the future of the native races of this country.

To apply the theory to the matter in hand is the next consideration.

As far as the physical attributes are concerned, everyone will agree that physically the Bantu peoples are persistent. There is no expectation of their dying out, nor of their rate of increase

being greatly diminished. Possibly it may be increased. So there is nothing to be said under this head, and no comparisons need be drawn for our purpose.

The next is the question of intellectual attributes. Reverting to the quotation I have previously given, I cannot in the slightest degree assent to the statement that there are very few natives in this territory able to rise beyond the educational ability of a child in the third standard. In so far as racial heredity is concerned, I am inclined to believe there is nothing to choose between the intellectual capacity of a white man and a Mashona or a Matabele. Given the same environment, it appears to me, after fourteen years' study of the native of this country, that his brain is capable of just as much development, and that he starts life equipped with just the same intellectual capabilities as a white man. I should put his stake of Racial Heredity into the ground of life exactly alongside the white man's in the sphere of intellectual attributes. The Environment, or Social Heredity, of intellectual activity he has not in the same degree. His chain of environment, within the limit of which he may roam, is much more restricted. The part of the future is to add links to that chain of Intellectual Social Heredity of the black man, as it is the part of the future to add links to the chain of Intellectual Social Heredity of the white man. Therein lies half of the problem of the future of the native races of Rhodesia. The other half we come to next.

We have dealt with the physical and intellectual spheres. We come now to the moral sphere. I class as moral virtues the following: mental vigour, moral stamina, the ability to accept responsibility, the instinct to accept responsibility, the capacity to take up a strong attitude towards life and all it means. These are absolute virtues. The other moral virtues as more usually meant, besides being relative, and, to some extent, a matter of fashion, are altogether dependent for their existence on the virtues I have named, and therefore I do not take them into account in this connection. In the moral sphere, as I have defined it in its virtues, we find the Racial Heredity of the Rhodesian native is not the same as that of the white man, the Western European. Therein it differs from the state of affairs in the intellectual sphere. In the moral sphere the state of Racial Heredity is not put down close to the white man's. That is the conclusion to which I have come. I may be wrong, and the out-and-out believers in the overwhelming influence of Social Heredity, Environment, will refuse to accept such a limitation upon any portion of humanity; but careful observation, both of my own and of many unprejudiced investigators in whom I have confidence, convinces me that the black man starts life with a certain innate difference from the white man in respect of those moral virtues which I have enumerated as absolute moral virtues. (The relative virtues I do not touch upon.) The black man's Racial Inheritance of absolute moral virtues is inferior to the white man's. And, for this reason, I say that our civilisation rests at present on the undisputed supremacy of the white man. For this reason I state there is no incompatibility between insisting that the white races shall be supreme and endeavouring to approximate the native races to the standards of the white

races. I deny that the two taken together imply hypocrisy. In the moral sphere, again, the chain of Environment which binds the black man to the stake of Racial Heredity is much shorter than the white man's corresponding chain. That, I think, no one will dispute. To add links to that chain is the other half of the problem of the future.

The stakes of Racial Heredity, one in each sphere, physical, intellectual, and moral, are immovable, except by a process of selective breeding which is and will remain a chimera. The chains of Environment, or Social Heredity, can be increased by adding links thereto. This applies to white races and black alike, and is the essence of progress.

Let us examine the problem for the black man.

The factors of the position to-day are these: We have native races, of a persistent physical type, with the intellectual capacity of Europeans, but hitherto extremely limited by Environment in the intellectual sphere, and in their capacity for absolute moral virtues inferior to Europeans by Racial Heredity and still more limited by Environment.

(NOTE.—The Matabele, superior to the Mashonas in their social heredity of moral attributes, are inferior to them as regards intellectual standards, but it is not necessary to deal with the two races separately. The difference is small, as compared with the distance separating them both from European standards, and I propose to treat of them together.)

The danger of the future lies in the development of the environment of the intellectual sphere without a corresponding development of the environment of the moral sphere.

This danger is no mere fancy. In intellectual matters there is every possibility of ever-increasing numbers of natives approximating more and more closely to European standards. I use the word "intellectual" in its widest sense to embrace all operations of mere brain power, and include manual dexterity in crafts, tradesmanship, business knowledge and acumen, knowledge of the learned professions, scholastic knowledge. With all due deference to what others may have said, I must insist that in this part of Africa there is bound to arise—there is arising now—an ever-growing class of native artisans approximating more and more to European standards of trade skill. Some of the trades and occupations followed to-day here in Bulawayo by independent natives are bootmaker, carpenter, mason, builder, tailor, laundryman, fruit merchant and hawker, wood-seller, vegetable-seller, mattress-maker, brassworker, painter, tobacconist, tinker, hide and skin merchant. Many manage stores and eating-houses. As the years go on their numbers and their skill will increase.

I will add another circumstance. Those who have studied native law, particularly the family laws of the Mashonas, and compared them with Roman law in its earliest stages, cannot but have been struck by the extraordinary likeness there is between them, and by the intellectual power shown in working out an harmonious system of law by the despised Mashona. There would probably be far less trouble needed to explain the Roman *patria potestas* and *manus* to an ordinary Mashona than would be required to make them clear to an English artisan.

Another point to which I wish to direct attention is this. The late Maurice Evans, in his study of the South American negro, found, as a racial characteristic, this defect. They seemed quite incapable of saving. It appeared to be the principal cause operating against their uplift. Now this is not a characteristic defect of the native of South Central Africa. Some of them are spendthrift, the bulk are parsimonious. I should put an ambition for solid wealth as one of their leading characteristics. This will act as a powerful incentive to them to develop as artisans, as members of the working and business community. Do not be misled because at present they mostly show a reluctance to work for white employers. Remember we have only been here one generation. As a nation they have still to size up the situation and realise the power of money. But I have known many individual natives who have grasped the idea firmly, and have settled down to a steady life of accumulation. Generally speaking, the native of this country is intellectually the superior of the American negro in most ways. His brain is more alert, more alive, and it will be a great mistake to draw too many analogies to the detriment of our natives from American negroes. Our natives here have not had generations of the shattering experience of slavery to restrict their intellectual environment.

Another factor which is vitalising the intellect of the Rhodesian native is the intermingling of races. I am not referring to any possible variation of racial heredity by intermarriage between races, but to the effect upon social heredity of many races coming in contact. Here in Bulawayo there are probably more languages spoken, more tribes represented, than in any other town of South Africa. When I first came to Bulawayo my household consisted of eight persons. We habitually, and in every day intercourse, used eight languages, two European, five native languages, and kitchen Kaffir. A few weeks ago I had in my office a native who spoke sixteen different and distinct languages. Such things as these lead to a considerable sharpening of ideas.

No, I cannot but feel that one or two generations will see, perhaps I should say may see, a great change in the intellectual development of the native. And I look forward with a great deal of misgiving to a time when this shall have occurred. I see a large body of natives, running into several thousands, skilled in the professions and crafts, skilled in farming and business, skilled in rhetoric and logic, intellectually as acute, perhaps as the Greeks, and with even less stability. Add to this, that they will be able to command considerable resources of money, owing to the national characteristic of being able to save money, and we have the stage set for tragedy.

Unless we can somehow develop their moral life, and their standard of living, we shall go under before them, as bad coinage drives out good. We must be animated by ideals, and we must be prepared to force our ideas to become realities, or we shall perish.

Some will say: "Yes, but why let things come to such a pass? Why let the native be educated? Why not leave him in his raw state? Why not introduce a stringent colour bar to

prevent the native ever growing away from his natural state?" Apart from any ethical aspect, apart from the question of the "right to rise," we do not do these things for the same reason that King Canute did not stop the rising tide. Whether we like it or not, intellectual development will reach these people. Their intellectual *milieu* is changing before our eyes.

Our hope of salvation lies in this—we must use every effort, we must bend the whole force of our national genius to this: that the moral development of the native shall proceed *pari passu* with the intellectual development. As a link is added to the chain of Intellectual Social Heredity, at the same time a link must be added to the chain of Moral Social Heredity. Incidentally we must take what steps are possible to ensure that the intellectually developing native makes full use of the lengthening chain of Intellectual Environment in all directions. Harmony is strength, and a healthy development demands harmonious development in all directions. But the essential desideratum is development of the Social Heredity, the Environment, of moral power, the creation of a *milieu* favourable to the absolute moral virtues, those virtues which I have before mentioned. Even if the Bantu races have a different Racial Heredity of Moral Power from the white races, an inferior heredity, so that they can never rise to the commanding political position of the white races, yet their environment in this matter can be vastly improved, and must be vastly improved, if we are to remove some of that characteristic of *fickleness* which has always been the vice of negro peoples. When negro races have been intruded into European institutions, where European institutions have been thrust upon negro races, the great cause of failure has always been in the moral rather than the intellectual sphere, and one of the most frequently recurring complaints has been fickleness. It is in the moral sphere we must concentrate our efforts, or we shall be shaped for disaster.

Do not think that the moral virtues will come as the intellectual development proceeds. They will not.

In discussing Labour Government, the average Englishman, sententious, says: "Of course, power and responsibility would be a great influence for moderation if ever we should have a Labour Government."

I fancy there is a scarce-formed, yet power-exercising, analogous idea abroad in respect of native intellectual development and moral steadiness. People say, or perhaps feel, without saying:—

> "Of course, as they develop on those various lines, approximating to European conditions in such and such a matter and in this, that, and the other thing, they will pick up ideas of stability, and responsibility. There will be agitators, of course, but the great mass will, as always, be slow to move."

That is a very, very great mistake. Nothing whatever in the history of black races bears it out. What stability they have shown in the past has always been in their independent state, when conditions have favoured the power being in the hands of those who in the moral sphere (in mental vigour, etc.) surpassed their fellows, and who, by their possession of absolute moral

virtues, were able to enforce stability on their fellows by savage methods. It was the absolute moral virtues of Chaka and Lobengula which made them so pre-eminent, and gave stability to the nations they ruled. Whenever black races have come under civilised or semi-civilised conditions, everything has proved the utter lack of foundation for any such belief in intellectual development resulting necessarily in moral development. With the passing of the leadership of native thought from the possessors of the moral strength to the possessors of intellectual strength, our one plain duty is, create a *milieu* favourable to the development of moral virtues, add link upon link to the chain of Moral Social Heredity. Stabilise. We have one factor in our favour, as compared with the United States of America, in facing our problem, the racial characteristic of saving, that I believe our Rhodesian natives possess.

I am a thorough-going believer in Benjamin Kidd's dictum that the collective emotion of the mass is almost infinitely more powerful than individual racial heredity, and that by a correct apprehension of methods the whole life of a nation can be modified in a very short space of time. Nations do change in their national characteristics. Nations have in the past changed extraordinarily. The French of 1890 and of 1910 were totally unlike, and also the Greeks of 1898 and the Greeks of 1912.

Before going any further, I wish to draw attention to one matter which is not generally appreciated. That is, the orientation of Southern Rhodesia in matters affecting natives. Usually in Native Affairs we feel that our kinship is with the Union of South Africa. We study their problems for the light they may throw upon ours, and probably *vice versa*. This, I believe, is wrong.

Although in matters affecting Europeans we are for the most part to be looked on as the most northern part of South Africa, in native matters we are, I submit, more to be regarded as the most southern part of Central Africa. The native problem in an acute form similar to our native problem affects only portions of the Union, *e.g.*, Zululand, Kaffraria. It pervades the whole of Rhodesia. In the Union the native, if not submerged, is at least submersible. In Rhodesia he is not submersible, he is insistent. In Rhodesia the native is more, the European less, in his proper latitude—the bulk of Southern Rhodesia is in the tropics. The mere fact that the major portion of the Union would be a perfectly good country for the white man even without a native in it, whereas the Rhodesian climate probably renders the black man an absolute necessity to the white man, marks a deep gulf between the two. It is possible that the passage of time and a policy of *laissez faire* would clarify the native problem in the south; with us it would merely intensify it. In the Union, except in certain secluded areas, the native will always be the helot of civic life, which will centre in the Europeans almost exclusively. In Rhodesia this cannot be. No, for common ground on native affairs we must look to the north. From a native point of view the barriers on the south of Rhodesia are much more formidable than those on the north, especially north of Mashonaland. The current of native life that flows to and fro between Southern

Rhodesia and the north is vastly greater than the corresponding flow to and from the south, and will increase proportionately as the years go on. We and the north will gradually assemble in native affairs; we and the south will gradually diverge. At the risk even of bordering upon politics, I will say that this state of affairs would not be altered even if we became part of the Union. We shall always be part of the Black North. We must face our problem in native sociology without assistance from the south.

Our problem, then, is twofold. Firstly, to ensure a social environment favourable to the growth of the moral side, which without assistance may not grow at all.

Secondly, to ensure a social environment favourable to the harmonious growth of the intellectual side, which without assistance will grow, but may grow inharmoniously, that is, unevenly.

There are three phases of native life to be considered. Firstly, the native artisans and labourers in towns and villages.

Secondly, the native labourers on farms and mines.

Thirdly, native life in reserves.

I am not pretending that there is any hard and fast line to be drawn between these existences, but they represent sufficiently different phases to be considered separately.

Taking the question of native labourers on mines and farms first, and coupling with them natives residing on farms under the Private Location Ordinance, very little can be done. Mine labourers are a very shifting class, and the real interest of their lives centres nearly always in their kraals, to which they return after a more or less extended stay at the mines. Farm labourers are partly birds of passage, like mine labourers, and partly permanent residents on the farms at which they work. In the latter case they are in a back-water. They are not a class which lends itself readily to any development, nor, if they were the only natives in the country, would the native problem be so vitally insistent. Our duty towards the native races would remain, but as the sanction for its enforcement would merely be our own disapproval, it might be considered with a great deal less anxiety, and the natives left to remain, as these particular natives probably will remain, in their helotage. The natives on farms are out of the main current of native life.

In towns we have a very different state of affairs. There is gradually growing up a distinct class of town "boy." The lead in the life of town natives is, of course, taken by the natives working in stores, offices, workshops, and factories. The number of natives taking to this life permanently is increasing each year Their aptitude for many of the positions they fill is undoubted, and grows yearly. Their general intelligence grows. Their wages certainly grow. We have here probably the most suitable class for our efforts in mass elevation. Working systematically, we could almost certainly effect a greater improvement in the intellectual and moral spheres in a given time with this class than with any other section of the native community. But at present everything is against their development, especially in moral virtues (meaning by moral virtues what I have previously so described: in the matter of what are more commonly reckoned as moral virtues, they are obviously very lacking, and their environment

is even more against them than that of other classes of natives). By nature they are inclined to beer and women, and beer and women are almost the only recreations offered them. If the beer in the Location Beer Hall is not strong enough for their taste, or they are not allowed to indulge in the riotous jollity commonly dear to the hearts of care-free young men when enjoying themselves in company, it is the easiest matter in the world to mount a bicycle and find a kraal where the brew is stronger and the licence more free. Almost every native woman they meet is loose, either by profession or as an amateur. Decent home life in a town location is almost an impossibility. Hardly any native who has a wife he does not wish to become common property will risk bringing her to town to live. It is small wonder that the more solid qualities have small encouragement to develop, and that the general environment is one of constant desire for excitement, and a giddy whirl of pleasure. With many the principle acted upon is "Eat, drink, and be merry, for to-morrow we shall have syphilis or be in gaol." This is not a healthy condition of affairs, and should be remedied. The remediation is not impossible. The human material is there. In spite of the conditions being so very much against them, there are many natives in town who do lead decent, thrifty, hard-working lives. But the atmosphere is against them, and as long as the present surroundings remain, the present result will continue. The first, the essential, alteration to make is in the town locations. The trouble with the present locations is that they only fulfil half the requirements. As Kipling says: "Single men in barracks don't grow into plaster saints." The present locations are admirably adapted to housing bachelors who are away at work all day. They are entirely unadapted to housing families of a race that is not strong in moral restraints. What can we expect of native women and men together in barracks?

In addition to the location of existing type, there must be semi-rural locations. The hopelessness of family life in the present locations springs from the fact that the women have nothing to do. Even if they had not generations of agricultural instinct behind them, and women, of course, are the great conservers of tradition and instinct; even if their traditions in any way at all made them suitable to town life, there is no possible niche for them to fit into, no outlet for their energies in the present locations. The locations of the future, the semi-rural locations, will be at a greater distance from town. Each hut will have an acre or more land allotted to it. The influence of the missionaries and officials of the locations will be directed to the creation of an atmosphere favourable to women, and men in their spare time, working in their gardens, taking a pride in them, realising the vast difference to the productiveness of the soil that is made by close and careful nursing and cultivation. This is not an idle dream, I feel sure. I am certain it can be accomplished. Then it will be possible for a tradition of decent family life in the locations to be created. It will be the case that men will settle in the locations permanently and bring up their families in honest pride. The boys of the family, at the impressionable age, will have the parental influence supporting the mission school influence in favour of decency and sobriety. The girls of the family, who will probably

replace to a great extent the house-boys, and still more, I hope, the nurse-boys at present employed, will feel the same influence, and will be able to keep straight. At present, for young natives of either sex location life is a thorough grounding in vice. The question of building cottages in these locations cheaply enough to let at a rental possible to the occupiers-to-be, and at the same time to make a return on the money invested, is not insoluble. This, and many other minor points about the semi-rural locations, I have not time now to go into, but of the soundness of the general idea I am convinced. So, and not otherwise, shall we render the town native a support to our civilisation, and not a perpetual menace thereto.

We come to the third phase of native life, life in the Reserves. At present, and more each year as time goes on, it is a fact that the brighter spirits among the new generations drift towards the towns. There the mind has more to grip, more is going on, life is written with a capital L, and every day has a freshness and an interest in it that appeals strongly, as strongly to black as to white. For the young man of an independent turn of mind, of an adventurous spirit, particularly if he has no inherited wealth of cattle, town life offers tremendous attractions. This is especially the type with the greatest possibilities of development of moral strength, in the meaning which I have previously attached to this word; this type offers the best material for our efforts to add links to the "social heredity" chain of moral attributes, to develop which is to be our principal aim. The very fact of these natives leaving the kraal life betrays a certain amount of originality in their composition.

Now the main current of native life will always be in the Reserves, the main current, if not necessarily the most noisy and violent. The larger the water the further run the ripples from the stone dropped in it. It is most essential that the brightest spirits amongst the natives, the best material for moral development, the people who we hope will prove the leaven by which our efforts will raise the mass, should not be lost to the Reserves. It is a matter of vital importance to the future of the native races that there should be sufficient attractions, and possibilities, in the Reserves to keep there those who possess the very qualities we wish to develop. The future of the natives lies in the Reserves; this must be so, for their good and for ours. It is on the outcome of development in the Reserves that the fabric of our civilisation mainly depends. We must see to it that the best material is available in the Reserves for our efforts.

To this end we must "vitalise" the Reserves. When I say "vitalise" I do not wish to be understood as saying that the native in the Reserve at present leads a life of slothful inertia and degradation. Very far from it. I have lived too long in native Reserves not to know that there is, it is not altogether an exaggeration to say, a busy hum of human activity going on continually, and audible to any ear in the least degree receptive. But for the object I have in view, the development of the moral attributes of originality, vigour, etc., and the other object of offering inducements to original spirits to stay in Reserves, this activity does not appear to be sufficiently formative. I think it should be linked

up with the outside world more closely by creating radial centres of development within the Reserves, rather than that European ideas should filter in slowly from outside by almost inperceptible channels. Therefore I say, "vitalise" the Reserves.

Next to law and order, "vitalisation" should be the main consideration in any proposal made in connection with Reserves. Any scheme for development should offer ideas to the native mind on which it can work, mental food as much as material prosperity. The desideratum is the evolution of the absolute moral virtues of vigour, stamina, energy, and, at the same time, the strengthening of the intellectual attributes of originality and readiness to accept education.

The bulk of the work of civilisation in the Reserves has been done by missionary societies, and will still be done by them in the future. The very reason of their being in the Reserves necessarily compels them to direct their efforts to the relative moral virtues, Christianity, cleanliness, sexual morality, etc., rather than to absolute moral virtues, which are, moreover, much more shadowy and indefinite. It is no more a criticism of the work done by missionaries to say this than it would be a criticism of a wicket-keeper to say that he thought more about stumping a man than clean bowling him. The conditions of a missionary's calling categorically demand that he should rank as highest certain moral attributes which I have classed as relative virtues (In using the words absolute and relative I have no idea of inferring any proposition as to inferior or superior.) The inculcation of these relative moral virtues may safely be left in the hands of the missionaries, who likewise deserve every credit for the work they have done in intellectual education. It is to the development of the absolute moral attributes, and the rounding off of the educational efforts that I wish to direct attention; and therefore I say, vitalise the Reserves.

The question of how this is to be done deserves a longer paper than time allows. I can only mention here shortly some of the steps that might be taken.

On the subject of industrial development of the Reserves, I must refer you to a report recently written by Mr. Keigwin, and published by the Southern Rhodesia Administration. If the policy bears fruit, we shall see a new type of kraal gradually evolved, what I may call a kraal town, more permanent than the present kraals. These towns will be industrial and trading centres, places for schools of craft and mission schools. In them, as a natural development of the kraal headman and the elders, there will be headmen (*i.e.*, Mayors) and Councils. Every effort should be made to vivify this civic life. It will be both a training and an outlet for energy, and the political instinct. The Parish Councils of England, which have been really a dismal failure, when contrasted with the glowing hopes that were entertained of them, were based upon a misconception. It was believed that the Parliament idea could be passed on from the nation to the parish. This was not so. Having tasted Parliaments nationally, the people of England could not be bothered to play at Parliaments parochially. There was, besides, always something artificial about Parish Councils. The folk memory retained perhaps sufficient unconscious recollec-

tion of tribe assemblies to be able to absorb county councils, and town councils were directly affiliated to mediæval and post-mediæval guilds, but parish councils seemed always more or less artificial. With this lesson in mind, we must be careful to build any civic or municipal institutions on the foundations we have, and be anxious rather for a natural development than for a theoretical perfection. The experiences of the native councils in those parts of the Cape Colony to which the Glen Grey Act has been applied will be valuable in this connection.

An important matter will be roads. A well-built road is an artery of life. In a way, all civilisation is founded upon locomotion. There is scarcely any other thing exercises so much humanising, civilising, vitalising influence on a locality as a grand trunk road.

The provision of wells, for drinking water and for irrigation, will be an affair of the local councils or authorities, guided and directed by the experts of central government.

Afforestation, for the provision of a sufficient supply of suitable timber for building, wagon-making, furniture-making, and all the other needs of a community, appears to be an object to be taken up by the central government, either directly or working through local bodies covering large areas.

A topic that has cropped up very often of late years has been that of individual native ownership of land. In this matter we must move slowly. Communities of natives have occasionally purchased farms as communal settlements. Such ownership, the necessity for which will disappear with a due development of the Reserves, and which is in itself a tribute to the strength of the innate prejudice in the mind of the native in favour of land being common, must not be confused with individual ownership. The individual purchases of farms by wealthy chiefs have really been made in the communal spirit, for their people as much as for themselves. There have also been a few, very few I believe, genuine individual purchases of land to be held as real private property. I am not sure about this last point, and am prepared to be told there have been none. If any demand should arise for individual tenure of land, it should, as far as possible, be satisfied by granting holdings adjacent to Reserves. But in satisfying this demand we should not hesitate to apply rigorously the excellent feudal conception that land cannot be a subject for mere commercial transactions, but carries with it obligations to the State, chiefly the obligation to support a certain number of citizens useful to the strength of the State. I would say that land should be granted merely for use, not for out-and-out ownership, and I would not be averse to surrounding land transactions with a halo of sanctity comparable to that surrounding the ancient Roman transactions in *res mancipi*. Subject to these limitations I would encourage individual tenure of land, as making for stability and the development of the moral attributes. I see a great future for the ideal of peasant proprietors who are likewise engaged in home industries and handicrafts. Neither is this idea inimical to the idea of more wealthy natives owning somewhat larger tracts of land to be farmed on the most up-to-date lines with modern machinery. Both may, and I hope will, come to pass.

The provision in Reserves of such things as sports centres, cinemas, hospitals, art schools, and many other things I have no time to touch upon, nor is there any need to do so. All I have in mind is to present to you the possibility and the desirability of vitalising native life in these localities where the mass of natives must reside, where the main currents of native opinion are formed.

And now I must close. I feel that I have been too discursive, and have touched all too lightly on many matters that require volumes for adequate treatment. All I have hoped to do is merely this:—

I have outlined a theory of physical, intellectual, and moral limitation of races, and racial development, which may at least be taken as a working hypothesis.

I have applied this hypothesis in the three different spheres to the native races of Southern Rhodesia, and stated my belief as to their relative state and capacity in each sphere, showing what is possible with the human material we have to deal with.

And I have, very shortly, outlined the steps which appear to be the first on the road of sound development of the intellectual and moral possibilities.

After fourteen years of life amongst natives I am neither an optimist nor a pessimist. Not an optimist, because I have daily experience of the difficulties of the situation: not a pessimist, because I see possibilities of success.

Taking what I believe to be a sane and reasonable view of all the factors and possibilities, I hope. And, if I live another fifty years in this territory, and can still hope, I shall be content.

My hope of the future is this: a State where everyone, white and black, makes full economic use of his abilities: where the black man shall not be shut out from any sphere of activity by a narrow and timid colour bar, and where the white man will reap the reward for his generosity in the opportunities arising from the immense economic development of a country in which he will be a directing and predominant partner.

Unless we have faith enough in our civilisation to submit it to the test of being used as a lever to raise the native, we shall pay the penalty, and the native question of the future will be a crumbling pillar in the political edifice. If we build with faith in what we stand for, we shall build buttresses for our civilisation.

A SHORT NOTE ON EINSTEIN'S PLANETARY EQUATION

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Read July 15, 1920.

§ 1.—Einstein's Relativity Theory of Gravitation, as given in Eddington's Report to the Physical Society (1918), involves much heavy, but, on the whole, satisfying, mathematical work. The results for the case of a point-centre of gravitation are that ds, the " interval " (including space and time) between two events is given by

$$-(ds)^2 = R^{-1}(dr)^2 + r^2(d\theta)^2 + r^2\sin^2\theta(d\phi)^2 - R(dt)^2 \; ; \quad . \quad . \quad . \quad . \quad (i)$$

and, hence, for a plane orbit (writing henceforward θ for ϕ),

$$\left(\frac{du}{d\theta}\right)^2 = 2mu^3 - u^2 + \frac{2mu}{h^2} - \frac{1-c^2}{h^2} ; \quad \left(u \equiv \frac{1}{r}\right)$$

where $R \equiv 1 - 2m/r$, m being merely a constant of integration, " constant " for *all* motion in the field of this point-centre;

$$h \equiv r^2\frac{d\theta}{ds} ; \quad \frac{c}{R} \equiv \frac{dt}{ds} ;$$ where h, c are constants for *any one orbit*.

r, θ, ϕ are (more or less) identified with ordinary polar co-ordinates. But, " the considerable freedom of choice of co-ordinates allowed by Einstein's equations " is invoked with disturbing frequency in order to sanction " the possibility of using any function of the radius vector instead of r itself." And we are told that we " may meet elsewhere with different expressions for the line-element due to a particle." The one used by Eddington was given by Schwarzschild. By means of it (and of the rather free modifications in the co-ordinate r referred to above) Eddington, following Einstein, obtains clearly enough the two great results by which the new theory claims to have improved on the old Newtonian theory —the theoretical advance of Mercury's perihelion, and the theoretical deflection of light by a field of gravitation, which seems to have been so triumphantly confirmed by the observation of the May, 1919, eclipse.

§ 2.—Two discrepancies in the work, arising from the free treatment of the radius vector are worth mentioning:—

1. As pointed out by Prof. Anderson, of Galway, in the *Phil. Mag.*, May, 1920, the special modification of r necessary to establish the deflection of light (Eddington, p. 53) would, if applied to the same fundamental equation (i) above, not give

the desired Mercury result. Whether this discrepancy can be at all accounted for by the fact that a ray of light is there treated as a travelling particle, I cannot say.

2. In Eddington's extension of the formula to the "gravitation of a continuous distribution of matter" (chap. vi, p. 59) an approximate result is obtained:—

$$-(ds)^2 = -(1+2V)(dx^2+dy^2+dz^2)+(1-2V)(dt)^2,$$

where $V=\Sigma(m/r)$, the Newtonian potential.

Apparently this result does not include the previous formula for a single particle as a special case—a somewhat surprising incident.

§ 3.—The main object of this Note is to call attention to a consequence of the second equation in § 1.

$$\left(\frac{du}{d\theta}\right)^2 = 2mu^3 - u^2 + \frac{2mu}{h^2} - \frac{1-c^2}{h^2} \quad \ldots \ldots \ldots \ldots \quad \text{(ii)}$$

The corresponding Newtonian equation is, of course,

$$(du/d\theta)^2 = -u^2 + \frac{2mu}{h^2} - \text{const., giving the elliptic orbits.}$$

On the fundamental principle that at a distance from the gravitating centre Einstein's equations must agree with Newton's, we identify, in the case of the solar system, Einstein's integration constant m with Newton's "mass" of the sun (in gravitation units).

Eddington solves equation (ii) by a rather unpleasing series of approximations. The straightforward and accurate elliptic-function solution is pointed out by Forsyth in *Nature* for 8th April, 1920, p. 186.

Re-writing (ii) in the form $\left(\frac{du}{d\theta}\right)^2 = 2m\,(u-\alpha)\,(u-\beta)\,(u-\gamma)$

where $\alpha>\beta>\gamma$, and at first assuming α, β, γ to be all real and positive, we see that u may either lie between β and γ, giving the ordinary two-apse orbit which, presumably, is indistinguishable by observers from Newton's ellipse,

or u may be greater than α, *i.e.*, r less than $\frac{1}{\alpha}$.

This case gives $\theta\sqrt{\frac{m}{2}} = \frac{1}{2}\int_u^\infty \frac{dt}{\sqrt{(t-\alpha)(t-\beta)(t-\gamma)}} \quad \ldots \quad \text{(iii)}$

Thus $u-\alpha$, $u-\beta$, $u-\gamma$ are the (semi-axes)² of that confocal ellipsoid which has internal potential $\theta\sqrt{m/2}$. Since, by elementary Elliptic Function Theory, these (semi-axes)² are periodic functions of the potential, the period being 2ω,

where $\omega=\frac{1}{2}\int_\alpha^\infty \frac{dt}{\sqrt{(t-\alpha)(t-\beta)(t-\gamma)}}$, we obtain a periodic orbit, the period of θ being $\omega/\sqrt{2m}$. And since equation (iii) makes this orbit go through the origin when $\theta=0$, we are reduced to a single-apse flight from the origin out to $u=\alpha$ and back in period $\omega/\sqrt{2m}$.

The three special cases in which the elliptic function degenerates will perhaps give the clearest idea of the shape of these inner orbits.

I.—If $\alpha=\beta=\gamma=1/6\mathrm{m}$ (in which case $1/\mathrm{h}^2=3\alpha^2=1/12\mathrm{m}^2$, and $(1-\mathrm{c}^2)/2\mathrm{mh}^2=\alpha^3$, $\therefore \mathrm{c}^2=\frac{8}{9}$)

$$\theta\sqrt{\frac{\mathrm{m}}{2}}=\tfrac{1}{2}\int_{\mathrm{u}}^{\infty}\frac{\mathrm{dt}}{(\mathrm{t}-\alpha)^{\frac{3}{2}}}=(\mathrm{u}-\alpha)^{-\frac{1}{2}}$$

$\therefore \mathrm{u}-\alpha=2/\mathrm{m}\theta^2$, a spiral only reaching $\mathrm{u}=\alpha$ when $\theta=\infty$.

II.—If $\alpha=\beta$:

$$\theta\sqrt{\frac{\mathrm{m}}{2}}=\tfrac{1}{2}\int_{\mathrm{u}}^{\infty}\frac{\mathrm{dt}}{(\mathrm{t}-\alpha)\sqrt{\mathrm{t}-\gamma}}=\int_{\sqrt{\mathrm{u}-\gamma}}^{\infty}\frac{d\tau}{\tau^2-\alpha-\gamma}=\frac{1}{\sqrt{\alpha-\gamma}}\coth^{-1}\sqrt{\frac{\mathrm{u}-\gamma}{\alpha-\gamma}}$$

$\therefore (\mathrm{u}-\gamma)=(\alpha-\gamma)\coth^2\left(\theta\sqrt{\tfrac{1}{2}\mathrm{m}(\alpha-\gamma)}\right)$, again a spiral leading to $\mathrm{u}=\alpha$ when $\theta=\infty$.

III.—If $\beta=\gamma$:

$$\theta\sqrt{\frac{\mathrm{m}}{2}}=\tfrac{1}{2}\int_{\mathrm{u}}^{\infty}\frac{\mathrm{dt}}{\sqrt{\mathrm{t}-\alpha}(\mathrm{t}-\gamma)}=\int_{\sqrt{\mathrm{u}-\alpha}}^{\infty}\frac{d\tau}{\tau^2+(\alpha-\gamma)}=\frac{1}{\sqrt{\alpha-\gamma}}\cot^{-1}\sqrt{\frac{\mathrm{u}-\alpha}{\alpha-\gamma}}$$

$\therefore (\mathrm{u}-\alpha)=(\alpha-\gamma)\cot^2\left(\theta\sqrt{\tfrac{1}{2}\mathrm{m}(\alpha-\gamma)}\right)$ which reaches its apse $\mathrm{u}=\alpha$ when $\theta=\pi/\sqrt{2\mathrm{m}(\alpha-\gamma)}$.

Of course, these results suggest visions of spiral nebulæ, corona, prominences, etc. But the following considerations disperse them rapidly.

§ 4.—Measurements of our solar planetary motions show that m=1·47 kilometres. [It will be noticed that the system of units adopted in the fundamental equations, in which the velocity of light=1, makes m and h of dimensions 1 in length or time, c being a number: and 1 sec.=3.10^5km., so that, for instance, the radius of the earth's orbit ≑ 500 secs.]

m=1·47 km. leaves no room for our "inner orbits" in the case of the sun. But there is no reason to suppose that the same objection would apply to other planetary systems: and there is no intrinsic objection in the theory to m being a minus quantity, and α, β, γ being minus, or β, γ conjugate imaginaries. The latter assumption would not seriously affect the above results, though the ordinary outer orbits would be impossible.

§ 5. $r=2m$ raises points of interest. We have then in equation (i) $R=0$, and $\frac{dt}{ds}=\infty$ (c cannot be zero; see below).

We have $r^2\frac{d\theta}{dt}=\frac{h}{c}R=0$; and $\frac{du}{dt}=\frac{du}{d\theta}\frac{d\theta}{dt}=0 \therefore \frac{dr}{dt}=0$.

$\therefore$ apparently, when $r=2m$, every particle comes to rest, and since the higher differential coefficients with regard to t also vanish, all motion ceases on $r=2m$.

Thus the "inner orbits" considered above reduce to spirals originating on the sphere $r=2m$, or to curves from points on $r=2m$ to apses on $r=1/\alpha$ and then back to $r=2m$.

§ 6.—To prove that these peculiarities of $r=2m$ are not ruled out by $c=0$, the equations connecting α, β, γ in § 3, viz.,

$$\alpha+\beta+\gamma=1/2m, \quad \beta\gamma+\gamma\alpha+\alpha\beta=1/h^2, \; \alpha\beta\gamma=(1-c^2)/2\,mh^2$$

give $(1-c^2)\,(\alpha+\beta+\gamma)\,(\beta\gamma+\gamma\alpha+\alpha\beta)=\alpha\beta\gamma$

$\therefore$ if $c=0$, $\;(\beta+\gamma)\,(\gamma+\alpha)\,(\alpha+\beta)=0$,

which is inconsistent with $\beta\gamma+\gamma\alpha+\alpha\beta=$ a square $(1/h^2)$.

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RAINFALL AND BAROMETRIC VARIATION IN BULAWAYO.

By Father E. Goetz, S.J., M.A., F.R.A.S.

Read July 15, 1920.

The average rainfall in Bulawayo for twenty-three seasons is:—

July	0·05 inches.
August	0·04 ,,
September	0·15 ,,
October	0·85 ,,
November	3·42 ,,
December	5·32 ,,
January	5·92 ,,
February	3·77 ,,
March	2·84 ,,
April	0·73 ,,
May	0·28 ,,
June	0·03 ,,

Year: 23·40 inches.

This table seems to indicate a fairly well distributed rainfall during the growing season, with a maximum in the middle of it. In reality, presented in this way it hides the fact that as often as not we have in the middle of the season—in December or January—prolonged droughts, which are very

detrimental to agriculture in Matabeleland. The effect of these droughts will appear very distinctly if we group the rains of December and January in periods of ten days. Summing up in this way the rain that fell from the 2nd of December to the 31st of January from 1897 to 1920, I get the following totals (the dates are inclusive):—

DECEMBER.

2—11	...	...	...	39 inches.
12—21	...	...	...	30 „
22—31	...	...	...	49 „

JANUARY.

1—10	...	...	...	31 inches.
11—20	...	...	...	46 „
21—30	...	...	...	45 „

In the second period of December the rainfall is 23 and 39 per cent., and in the first period of January 36 and 33 per cent. lower than in the periods immediately preceding or following. These partial minima are due to breaks in the rains that often occurred in December or January.

In correlating the expansion of the barometric monthly means into a sine series, with these droughts, I have come across the curious fact that the second harmonic seems to bear a very close relation with the variation of the rainfall, roughly, between the middle of November and the middle of February.

In the following table I give the date of the maximum or minimum of the term $A_2 \sin (U_2 + 2x)$ and the rainfall around that date. The table is given for twenty-two seasons, from July, 1897, to July, 1920. The season 1901-02 is omitted, as there was a break in the barometric observations. In seventeen seasons the maximum falls in a period of drought or of serious shortage in the rains, and the minimum in a period of excessive rains. In four seasons there is a period of drought immediately preceding or following the maximum. In one season, 1918-19, the maximum falls in the middle of a period of good rains, preceded and followed by a notable shortage of the rains. In each case I have given to the nearest half-inch the average rainfall for twenty-three years during the period under consideration.

BULAWAYO.

Relation between the Rainfall and the term $A_2 \sin(V_2 + 2x)$ of the Barometer.

A in thousandths of an inch; V in degrees; $x = 0$ on July 15th.

Term $A_2 \sin(V_2 + 2x)$					Rainfall at Maximum					Rainfall at Minimum				
	A_2	V_2	Maximum on	Minimum on	From	To	Amount	Days of Rain	Average Amount	From	To	Amount	Days of Rain	Average Amount
							Inches.		Inches			Inches.		Inches.
1897—98	26	96	Jan. 10	—	Jan. 8	Jan. 15	0·01	1	2	—	—	—	—	—
98—99	21	133	Dec. 21	—	Dec. 9	Jan. 18	0·00	0	7	—	—	—	—	—
99—00	5	55	Jan. 30	—	Feb. 1	Mar. 3	0·16	7	4	—	—	—	—	—
00—01	12	178	Nov. 30	—	Nov. 18	Dec. 4	0·44	4	3	—	—	—	—	—
02—03	48	165	Dec 7	—	Nov. 25	Jan. 1	0·27	3	6·5	—	—	—	—	—
03—04	14	152	Dec. 13	—	Dec. 1	Dec. 24	0·35	5	4	—	—	—	—	—
04—05	12	356	—	Dec. 1	—	—	—	—	—	Nov. 26	Dec. 16	4·81	11	3
05—06	16	119	Dec. 29	—	Dec. 17	Jan. 7	0·00	0	3·5	—	—	—	—	—
06—07	12	123	Dec. 27	—	Nov. 3	Dec. 26	1·06	7	7·5	—	—	—	—	—
07—08	28	112	Jan. 2	—	Jan. 2	Jan. 24	0·34	7	4	—	—	—	—	—
08—09	21	123	Dec. 27	—	Dec. 25	Jan. 7	0·26	3	2·5	—	—	—	—	—
09—10	26	161	Dec. 8	—	Nov. 1	Dec. 8	2·70	11	4·5	—	—	—	—	—
10—11	26	226	Nov. 6	Feb. 6	Nov. 2	Nov. 20	0·20	2	2	Feb. 14	Mar. 1	10·04	10	2
11—12	9	48	Feb. 4	—	Feb. 1	Feb. 18	1·10	1	2·5	—	—	—	—	—
12—13	19	132	Dec. 23	—	Oct.	Feb.	2·41	15	15	—	(General	Drought)	—	—
13—14	11	142	Dec. 19	—	Dec 1	Jan. 4	1·00	5	6·5	—	—	—	—	—
14—15	10	288	—	Jan. 4	—	—	—	—	—	Nov. 22	Feb. 1	26·19	68	12·5
15—16	9	49	Feb. 3	—	Jan. 23	Mar. 15	1·16	4	6·5	—	—	—	—	—
16—17	17	16	Feb. 20	—	Feb. 1	Mar. 20	0·75	6	4·5	—	—	—	—	—
17—18	25	315	—	Dec. 21	—	—	—	—	—	Dec. 6	Feb. 19	25·90	56	13
18—19	10	117	Dec. 31	—	Dec. 25	Jan. 5	3·48	11	2	—	—	—	—	—
19—20	14	203	Nov. 17	Feb. 17	Nov. 7	Nov. 25	0·09	1	2·5	Feb. 14	Mar. 9	9·02	18	5

In 1918 19 the maximum was preceded from December 6 23 by a drought with one shower of 1·25 inches (average 3 inches), and followed by a break from January 4 18 with a rainfall of 0·11 inches in 4 days (average 3 inches).

The coincidences are certainly remarkable. Whether a longer series of observations will confirm them is, of course, an open question in the case of such an erratic variable as the rainfall in our latitudes.

BAT GUANO DEPOSITS OF RHODESIA.

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Read July 15, 1920.

The scarcity of fertilisers during recent years has led to considerable prospecting being done in connection with bat guano deposits, and caves have been discovered in various parts of Rhodesia. From the records in the Agricultural Laboratory, Department of Agriculture, Salisbury, samples have been received from Sinoia, Mazoe, Darwendale, Gwelo, Gatooma, Que Que, Figtree, Melsetter, etc.

From an agriculturist's point of view, "guanos" have been highly prized in the past on account of their rapid action on crops, but, unfortunately, the term "guano" has almost lost it true value to-day, as we find many articles offered for sale that have no right to have the term "guano" affixed. Several bat guanos that were placed on the South African market came under my observation during 1917, and the results of analysis proved that they were of no commercial value—in fact, many soils would contain the same manurial equivalent. The average composition of four samples of (so-called) bat guanos was as follows:—

Nitrogen.	Phosphoric Oxide.	Potash.
Per cent.	Per cent.	Per cent.
0·20	0·56	0·02

"Guano," as defined in the Regulations of the Fertilisers Ordinance in force in Southern Rhodesia, means solely the collected excreta of sea birds. Excreta of bats, steamed, boiled or powdered fish or fish refuse and whale scrap may be sold under the names "bat guano," "fish guano" or "whale guano," as the case may be, and not simply as "guano." In any case, where the word "guano" is not preceded by the qualifying terms "bat," "fish" or "whale," it shall be taken to mean solely the collected excreta of sea birds.

Occurrence and Mode of Formation.—In almost every instance these caves occur in limestone formation, and the deposit consists almost entirely of the excreta and remains of bats, which have inhabited the caves from time immemorial. In some caves the remains of native calabashes and bones of animals have been found, pointing to the fact that in some remote age the caves had been inhabited by native tribes. This fact was borne out when I made an inspection of a series of caves in the Gatooma district, reference to which will be made later on.

If the deposit occurs in a dry cave or caves, and was formed under the most favourable conditions, the excreta would remain dry and in an unchanged condition, and one would probably find the bat guano to contain practically all the nitrogen, phosphoric oxide and potash originally present in the manure.

In a semi-tropical climate such as we have in Rhodesia, and where the deposit occurs on limestone formation in damp caves, the rate of decomposition due to bacterial action would be very rapid, resulting in the loss of a large amount of the organic nitrogen, the nitrogen being converted into volatile ammonium carbonate. Any water percolating in the caves would leach out the soluble nitrates and other water soluble constituents, resulting in the material containing but a small amount of nitrogen with a somewhat high content of phosphoric oxide.

It is probable that the above facts account for such a variation in the composition of bat guano.

Definition of Bat Guano and Guano Phosphate.—Bat guano, as defined in the Regulations of the Fertilisers Ordinance, must contain at least $2\frac{1}{2}$ per cent. of nitrogen and 8 per cent. of nitrogen and phosphoric oxide taken together. Guano from which all, or practically all, the nitrogen has disappeared shall not be sold as "guano," but may be sold as "phosphatic guano" or "guano phosphate."

Bat guano may be classified as follows:—

- Nitrogenous bat guano.
- Phosphatic bat guano or bat guano phosphate.
- Inferior bat guano. These are so poor in plant food that they are of no commercial value, except on the farm on which the deposit occurs.

Nitrogenous Bat Guanos.—These occur in a dry cave, and contain all the plant foods—namely, nitrogen, phosphoric oxide and potash. The nitrogen content of bat guano is of a complex nature, as such nitrogen may exist in several forms—(a) nitric, (b) ammoniacal and (c) organic. All these forms are of different availability to plant growth. Plants during their growth can make immediate use of the nitric

form, whereas the other forms have to undergo changes due to bacterial action before they can be assimilated by plants in general; therefore, in an application of bat guano there may be a gradual supply of available nitrogen. It is no doubt due to the above facts that the (supposed) superiority of "guanos" over other artificial fertilisers has been assigned.

Phosphatic Bat Guanos.—It is in damp caves, where bacterial action has taken place and possibly the deposit has been subjected to leaching, that phosphatic bat guano is formed.

Bat Guano Deposits Occurring in the Gatooma District: Umniati and N'Gondoma Caves.

A.—Umniati Caves.

These are situated 47 miles north-west from Gatooma, on a hill lying about 800 yards from the Umniati River. On this hill four limestone caves have been located, three of which are designated by the owners Nos. 1, 1A and 2, whilst the fourth has not yet been examined owing to the difficulty of gaining entrance thereto.

Description of Cave No. 1.—This is the principal cave of the Umniati group, the entrance to it being located on the lower side of the hill. In short, this cave may be described as consisting of a series of chambers, in the walls of which there are recesses in all sides. The chambers, the roofs of which are either dome-shaped or more or less flat, vary considerably in shape and size. The main chamber is, roughly, 30 feet wide by 40 feet long.

Among the most interesting features, apart from the actual guano deposits, in these chambers are:—

(a) The light yellow, snow white or reddish colour of the roof.

(b) The dependent stalactites and the presence in the walls of narrow vertical seams of white quartz, ranging from one-eighth to one-half inch in thickness.

(c) The intense heat in the more remote portions of the cave, comparable with that of a Turkish bath.

(d) The variation in the colouring of the guano deposit at depth, brown, white, black, yellow and red colours being noted in one section to a depth of eight feet from the surface.

(e) The immense number of bats, some of which have a wing spread of more than two feet.

The vastness of the number will be appreciated from the fact that for an hour after sunset I witnessed a continuous

stream of them emerging from the cave in mass formation, and at the end of that period the stream showed no signs of abatement.

At the time of my visit, most of the surface accumulation of guano in the main chamber had been removed to a depth of two feet. The actual depth of the deposit still remaining has not, however, been definitely determined beyond proving that it extends more than eight feet below the present level. It is impossible to give any idea of the extent of the deposit, as the entrances to the side chambers in some cases are only large enough to enable one to crawl through, and in others they are so completely filled with the guano that the presence of the chambers is not discovered until the deposit lying in front of the entrances thereto has been removed.

Method of Working the Deposit.—At present the material is all carried out of the cave by hand and sifted through a quarter-inch sieve, the material which fails to pass through the sieve being discarded. The sifted material is then packed to a depth of twelve inches on the floor of a drying shed adjoining the cave, and continually raked over for three to four days before being placed in bags and consigned to the factory in Salisbury, where it undergoes further grinding, mixing and air-drying before being sold. At the time of my visit I was informed that over 250 tons of guano had been withdrawn, principally from the main chamber.

Particulars of Samples.—From this cave the following samples were drawn for purposes of analysis:—

Lab. No. 117 G.—Average sample of the surface layer to a depth of 15 inches taken from most of the available chambers.

Lab. No. 118 G.—Average sample taken from the west side of the main chamber to a depth of 15 inches. This portion of the deposit is much damper than that from which No. 117 G sample was drawn.

Lab. No. 119 G.—Average sample of 20 tons of guano which had been withdrawn principally from the main chamber of the cave.

Lab. No. 120 G.—Average sample taken from the section two to seven feet below the original surface of the deposit in the main chamber.

Lab. No. 121 G.—Average sample of soft yellow nodules occurring in the deposit on the north-east side of the main chamber.

The samples were air-dried, and sifted through a quarter-inch sieve to remove stones, etc. The following are the results of analysis of the air-dried material after the samples had been passed through a one-millimetre sieve:—

Lab. No.	Nitrogen.	Phosphoric Oxide.			Potash.
		Water soluble.	2 per cent. Citric Acid soluble.	Total.	
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
117 G	2·87	0·35	7·89	11·33	0·35
118 G	10·31	2·35	4·67	5·12	2·29
119 G	1·24	0·84	6·92	11·85	0·44
120 G	1·27	0·91	16·73	22·71	0·40
121 G	1·59	1·18	29·68	31·32	—

These samples may be classified as under:—

Nitrogenous bat guano—Lab. Nos. 117 G and 118 G.

Phosphatic bat guano—Lab. Nos. 119 G, 120 G and 121 G.

I would draw attention to high availability of the phosphoric oxide in these samples, especially in the case of sample Lab. No. 121 G. With the exception of sample Lab. No. 118 G, all the remaining samples are poor in potash.

Umniati Cave No. 1A.—I regret it was impossible to form any idea as to the size of this cave, which lies about 200 yards east of Cave No. 1, or of the nature of the deposit therein, as it was only discovered a few days previous to my visit, and the present entrance is only large enough to enable a piccanin to get through. From this cave, which is apparently of large size, a small quantity of brownish-coloured material, represented by Lab. No. 122 G, was obtained.

The following are the results of analysis of air-dried material after being sifted through a one-millimetre sieve:—

Lab. No.	Nitrogen.	Phosphoric Oxide.			Potash.
		Water soluble.	2 per cent. Citric Acid soluble.	Total	
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
122 G	0·17	0·34	2·10	5·35	0·24

This sample should be classified as an inferior phosphatic guano, so low in quality as to possess little or no commercial value.

Umniati Cave No. 2.—This cave lies 100 yards west of Cave No. 1, the entrance thereto being on the slope of the

hill. The cave, which is situated about 80 yards from the entrance, consists of one large chamber, 35 feet wide by 70 to 80 feet long, with side chambers that have not been prospected up to the present. Prior to my visit the upper layers of the guano in this cave had been removed. A brownish guano, represented by Lab. No. 123 G, was selected from various places in the remaining deposit to a depth of 15 inches.

The following are the results of analysis on the air-dried material after being sifted through a one-millimetre sieve:—

Lab. No.	Nitrogen.	Phosphoric Oxide.			Potash.
		Water soluble.	2 per cent. Citric Acid soluble.	Total.	
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
123 G	0·81	0·06	2·63	5·39	0·36

This sample should be classified as an inferior phosphatic guano, and the remarks made in reference to sample No. 122 G apply thereto.

B.—N'GONDOMA CAVE.

This cave is situated in a hill about 37 miles east of the Umniati caves, and about 43 miles west of Gatooma, its name being derived from the N'gondoma River, which flows on the east side of the hill. The cave, so far as at present known, consists of a series of chambers, the largest of which is oval in shape and has an average dimension of 300 by 60 feet. The chamber is surmounted by a dome, which at its highest point is about 40 feet above the surface of the deposit. Through the overhead rock, which is about 40 feet in thickness, a natural shaft leading into the main chamber is provided. The vertical distance from the mouth of the shaft to the surface of the deposit is thus about 80 feet. Another entrance to the main chamber of the cave is provided from the side, but, owing to its irregular nature, it cannot be used in its present state for the removal of the deposit, consequently the guano is now being hoisted by means of a windlass through the natural vertical shaft referred to above. The extent of the N'gondoma deposit must be very considerable, as it has been proved in some places to be over 20 feet in thickness.

Particulars of Samples.—From the main chamber of this cave the following samples were taken for analysis:—

Lab. No. 124 G.—Average sample of the surface layer to a depth of 4 feet, about 80 feet from centre of cave.

Lab. No. 125 G.—Average sample of the surface layer to a depth of 15 inches, near centre of cave.

Lab. No. 126 G.—Average sample of the surface layer to a depth of 12 feet, near centre of cave.

Lab. No. 126 BG.—Average sample of the portion of the deposit lying 12 to 14 feet from the surface.

The samples were air-dried, and sifted through a quarter-inch sieve to remove stones, etc. The following are the results of analysis of the air-dried material after the samples had been passed through a one-millimetre sieve:—

Lab. No.	Nitrogen.	Phosphoric Oxide.			Potash.
		Water soluble.	2 per cent. Citric Acid soluble.	Total.	
—	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
124 G	9·26	1·41	7·32	7·53	1·98
125 G	5·24	1·21	10·32	12·69	2·52
126 G	1·40	0·61	6·41	16·89	1·79
127 B G	0·49	0·11	0·13	14·99	2·63

The classification of the above samples is as follows:—

Nitrogenous bat guano—Lab. Nos. 124 G and 125 G.

Phosphatic bat guano—Lab. Nos. 126 G and 126 BG.

I would draw attention to the high solubility of the phosphoric oxide in samples Nos. 124 G and 125 G, as against the low amounts in samples Nos. 126 G and 126 BG. Samples Nos. 124 G and 125 G were of a fine, uniform dry texture.

Extent of Deposits.

Whilst it is impossible to give any idea of the amount of material in these caves owing to their irregular nature, one, however, is justified in saying that many thousands of tons exist, and the material as found in the Umniati Cave No. 1 and the N'gondoma Cave is of considerable value.

General Nature of Bat Guano Deposits.

It is in the upper layers of the deposit that most of the nitrogen occurs, with a fair amount of phosphoric oxide. After the top layers are removed, the percentage of nitrogen decreases, with an increased amount of phosphoric oxide. The amount of phosphoric oxide soluble in a weak acid solution, such as a 2 per cent. citric acid, varies considerably,

one sample being as low as 0·13 per cent., whereas in another 29·68 per cent. was obtained. In the majority of deposits, with few exceptions, bat guano is very deficient in potash.

The results of analyses of numerous samples of bat guano deposits, even from the same locality or cave, indicates that the material varies greatly in composition. The following analyses will clearly illustrate the variations in composition:—

Nitrogen.	Phosphoric Oxide.	Potash.
Per cent.	Per cent.	Per cent.
11·37	3·60	1·16
1·59	31·32	—
1·29	12·24	4·67
0·08	0·39	0·08

AVERAGE COMPOSITION OF BAT GUANO—SOUTHERN RHODESIA.

The minimum, maximum and average composition of samples analysed from Southern Rhodesia is as follows:—

Nitrogen.	Phosphoric Oxide.			Potash.
	Water soluble.	2 per cent. Citric Acid soluble.	Total.	
Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Min. 0·8	trace	0·13	0·39	0·95
Max. 11·37	3·08	29·68	31·32	4·67
Aver. 3·53 *	0·93 †	6·75 †	8·70 *	1·16 *

* Calculated on forty-five samples.
† Calculated on twenty-six samples.

The following are the analytical results of samples analysed in the laboratory.

The samples have been classified as (a) nitrogenous bat guanos, (b) phosphatic bat guanos, and (c) inferior bat guanos. Included in the last classification are those that do not pass the standard as laid down in the Fertilisers Ordinance Regulations.

TABLE I.—NITROGENOUS BAT GUANOS.

Lab. No.	Locality.	Nitrogen.	Phosphoric Oxide. Water soluble.	Phosphoric Oxide. Citrate soluble.	Phosphoric Oxide. 2 per cent. Citric Acid soluble.	Phosphoric Oxide. Total.	Potash.	Lime.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
20	Figtree - - -	8·08				4·10	1·94	2·26
47	Sinoia : Lomagundi -	9·94			—	4·83	1·75	
141	Lomagundi - -	5·28		—		4·23	0·92	—
505	Northern Rhodesia -	2·62	—	—	—	10·31	0·20	—
778	Que Que - - -	10·13	—			7·03	3·70	
3.172	Main Belt Block : Gwelo -	5·95		—	—	3·67	1·50	
37 G	Gatooma - - -	4·52	1·34	2·95	3·56	4·85	0·61	14·98
40 G	Gatooma - - -	4·40	0·69	2·03	2·50	5·41	1·03	1·93
103 G	Gatooma - - -	3·99	1·29	—	4·27	13·11	1·10	7·45
128 G	Gatooma - - -	4·53	0·25	—	3·02	4·73	0·80	—
129 G	Gatooma - - -	7·79	3·08	—	16·00	17·37	1·24	—
130 G	Gatooma - - -	10·24	0·92	—	5·07	5·28	0·95	—
133 G	Gatooma - - -	4·37	1·05	—	2·07	14·80	1·27	
117 G	Gatooma - - -	2·87	2·14		7·89	11·33	0·35	—
118 G	Gatooma - - -	10·31	3·35	—	4·67	5·12	2·29	—
124 G	Gatooma - - -	9·26	1·41	—	7·32	7·53	1·98	—
125 G	Gatooma - - -	5·24	1·21		10·32	12·69	2·52	—
114 G	Mazoe - - -	11·37	2·81	—	3·04	3·60	1·16	—
202 G	Que Que - - -	3·72	—	—	—	8·51	1·07	
	Average -	6·56	1·54	2·49	5·81	7·81	1·39	6·65
	No. of Samples	19	12	2	12	19	19	4
		Min. 2·62 Max. 11·37	Min. 0·25 Max. 3·08	Min. 2·03 Max. 2·95	Min. 2·07 Max. 16·00	Min. 3·60 Max. 17·37	Min. 0·20 Max. 3·70	Min. 1·93 Max. 14·98

Table II.—PHOSPHATIC BAT GUANOS.

Lab. No.	Locality.	Nitrogen.	Phosphoric Oxide. Water soluble.	Phosphoric Oxide. Citrate soluble.	Phosphoric Oxide. 2 per cent. Citric Acid soluble.	Phosphoric Oxide. Total.	Potash.	Lime.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
48	Sinoia : Lomagundi	1·78		—	—	16·87	4·54	—
142	Lomagundi	1·73	—	—	—	11·45	4·31	—
506	Northern Rhodesia	1·22	—	—	—	10·48	0·26	—
39 G	Gatooma	2·20	1·36	13·89	16·85	18·96	1·17	15·24
41 G	Gatooma	1·67	1·27	17·71	19·23	21·64	0·42	13·55
102 G	Gatooma	2·17	0·86		3·06	10·50	0·79	7·61
127 G	Gatooma	0·55	0·17	—	0·89	9·50	0·37	
119 G	Gatooma	1·24	0·84	—	6·92	11·85	0·44	
120 G	Gatooma	1·27	0·91		16·73	22·71	0·40	—
121 G	Gatooma	1·59	1·11	—	29·68	31·32	—	—
126 G	Gatooma	1·40	0·61	—	6·41	16·89	1·79	—
126 BG	Gatooma	0·49	0·11	—	0·13	14·99	2·63	
241 G	Melsetter	1·29	—	2·88		12·24	4·67	
	Average	1·43	0·80	11·49	11·10	16·11	1·81	12·13
	No. of Samples	13	9	3	9	13	12	3
	Min.	0·49	0·11	2·88	0·13	9·50	0·37	7·61
	Max.	2·20	1·36	17·71	29·68	31·32	4·67	15·24

TABLE III.—BAT GUANOS (INFERIOR.).

Lab. No.	Locality.	Nitrogen.	Phosphoric Oxide. Water soluble.	Phosphoric Oxide. Citrate soluble.	Phosphoric Oxide. 2 per cent. Citric Acid soluble.	Phosphoric Oxide. Total.	Potash.	Lime.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
2,556	Sinoia Caves	3·70	—	—	—	2·70	0·31	—
2,557	Sinoia Caves	0·76	—	—	—	0·76	0·13	—
2,801	Darwendale : Lomagundi	2·45	—	—	—	2·28	0·07	—
2,966	Not given	0·36	—	—	—	1·15	0·05	—
3,168	Redcliffe : Gwelo	3·40	—	—	—	3·33	0·22	—
3,169	Redcliffe : Gwelo	0·47	—	—	—	6·30	0·16	—
3,170	Redcliffe : Gwelo	0·23	—	—	—	3·24	0·26	—
3,171	Redcliffe : Gwelo	0·12	—	—	—	7·32	0·68	—
3,173	Main Belt Block : Gwelo	0·08	—	—	—	0·39	0·08	—
38 G	Gatooma	1·00	trace	0·64	1·63	3·68	0·29	9·61
104 G	Gatooma	2·34	0·46	—	0·88	3·71	0·57	0·84
131 G	Gatooma	2·11	0·27		1·20	5·04	0·78	—
132 G	Gatooma	1·49	0·14	—	0·99	4·02	0·24	—
122 G	Gatooma	0·17	0·34	—	2·10	5·35	0·24	—
123 G	Gatooma	0·81	0·06	—	2·63	5·39	0·36	—
	Average	1·30	0·21	0·64	1·50	3·64	0·30	5·22
	No. of Samples	15	6	1	6	15	15	2
		Min. 0·08 Max. 3·70	Min. trace Max. 0·46	Min. Max. 0·64	Min. 0·48 Max. 2·63	Min. 0·39 Max. 6·30	Min. 0·05 Max. 0·78	Min. 0·84 Max. 9·61

Manurial Trials—Bat Guano.

The only reliable field trial with a nitrogenous bat guano on red diorite soil was conducted as early as 1912 at the Gwebi Experiment Station by Blackshaw,* who reported an increased yield over the unmanured plot of over two and a quarter bags of maize per acre.

The composition of the bat guano used in the trial was as follows:—

Nitrogen	5·28 per cent.
Phosphoric oxide ...	4·23 ,,
Potash	0·92 ,,

When applied at the rate of 200 lbs. per acre, the result was as follows:—

Bat guano plot	1,712 lbs.
Nil plot	1,248 ,,
Increase due to manure ...	464 lbs.

Whilst it is impossible to give any reliable returns of the results of field trials on this season's maize crop from applications of nitrogenous bat guano, phosphatic bat guano or bat guano supplemented by wood ashes on red diorite soils, there are indications, however, of some interesting results being obtained.

On a black vlei soil in the Makwiro district the increase due to an application of a general guano fertiliser, which consisted of approximately 70 per cent. of bat guano, was two and three-quarter bags of maize.

The guaranteed composition of the general guano fertiliser used in the above trial was as follows:—

Nitrogen	3·00 per cent.
Phosphoric oxide:	
Water soluble ...	0·32 ,,
2 per cent. citric acid soluble ...	6·95 ,,
Total ...	9·50 per cent.
Potash	3·00 ,,

When applied at the rate of 250 lbs. per acre, the following results were obtained:—

Guano plot	1,544 lbs.
Nil plot	1,002 ,,
Increase due to manure ...	542 lbs.

* Bulletin No. 124. August, 1912.—*Dept. of Agric., Salisbury*

Compound Fertilisers.

Bat guano, from the standpoint of the agriculturist, is a poorly-balanced manure, yet in many instances the mere addition of sulphate of potash would make an excellent fertiliser. In certain other cases, the addition of nitrate of soda, superphosphate and sulphate of potash for providing some readily available plant food, would result in an ideal fertiliser suitable for most crops.

Nitrogenous bat guano, in conjunction with wood ashes, should prove a suitable fertiliser for maize and tobacco. Blackshaw* has recommended the following dressing per acre for maize and tobacco:—

Maize: 600 lbs. wood ash; 150 lbs. nitrogenous bat guano (4 per cent. of nitrogen).

Tobacco: 1,000 to 2,000 lbs. of wood ash; 300 lbs. nitrogenous bat guano (4 per cent. of nitrogen).

Wood ash should be broadcasted over the land after the first ploughing and thoroughly harrowed in, and the bat guano applied broadcasted just before planting and lightly harrowed in. Bat guano and wood ash should on no account be mixed before application, as loss of nitrogen would occur.

General Conclusions.

The bat guano in many of the caves is of considerable value, and, when made up to approved formula with approved ingredients and sold at a price which is relatively cheaper than imported or other fertilisers, should be in great demand.

It is very doubtful if the bulk of the deposits would bear the cost of treatment with sulphuric acid for converting ammonium carbonate into non-volatile ammonium sulphate, and for rendering the phosphoric oxide soluble in water, as in the majority of cases the phosphoric oxide is too low.

Purchasers of bat guano should insist on being supplied with a guaranteed analysis, owing to the material varying so much in composition.

* G. N. Blackshaw (Oct., 1919)—Fertilisers for maize and tobacco. —*Rhodesian Agric. Journal*, pp. 456-459.

MAGNESIA IMPREGNATED SOILS.

By G. N. Blackshaw, O.B.E., B.Sc., F.I.C.

Read July 17, 1920.

This paper deals with certain soils, occurring on the so-called Great Dyke in Southern Rhodesia, which present features of particular interest to the agricultural chemist on account of their somewhat uncommon chemical character.

My attention was first drawn to these soils in the year 1912, when samples were submitted for analysis owing to the poor returns of maize which had been obtained.

These samples comprised red, chocolate and black loams which, from superficial observation, would appear to possess a considerable reserve of fertility. Although this did not prove to be the case on chemical examination, yet the cause of the particularly poor returns could not be attributed to lack of plant food. The analyses, however, revealed the presence of an abnormally large amount of magnesia in the soils, the ratio between the lime and magnesia being such as to lead one to suspect that the poor results were due to the excessive amount of the latter constituent.

From particulars supplied by Mr. H. B. Maufe, Director of the Rhodesian Geological Survey, it was found that the samples had been obtained from areas situated on the Great Dyke, which is about four miles wide and extends over a distance of approximately three hundred miles from the Umvukwe Hills, on the Lomagundi-Mazoe border, to the Doro Hills, in Belingwe. This dyke generally forms higher ground than the neighbouring country, and consists of norite, serpentine and other basic igneous rocks characteristically rich in magnesia, the presence of which affords an explanation for the high proportion of magnesia in the soils derived therefrom.

In the United States and Japan a considerable amount of work upon the relation between calcium and magnesium with respect to plant nutrition has been carried out, and a selection of the literature has been made in the present discussion with a view to presenting some of the ascertained facts as concisely as possible. These data are largely drawn from a very interesting review on the subject compiled by McCool.* As early as 1814 Davy† discussed the injury that magnesia sometimes produces on crops. He wrote: "On mixing some calcined magnesia with soil in which different seeds are sown, it is found that they either die or vegetate in a very imperfect manner." He also stated "that lime from magnesia limestone may be

* McCool: "The action of certain nutrient and non-nutrient bases on plant growth." Cornell University Agricultural Experiment Station, U.S.A., 1913.

† Davy: "Elements of Agricultural Chemistry," 2nd ed., p. 281.

applied in large quantities to plots and where lands have been injured by the application of too large quantities of magnesia lime, peat will be a proper and efficient remedy."

The deleterious influence of magnesian lime on crop production was reported by the United States Commissioner for Agriculture in 1876, and Adolf Mayer* in 1886 mentions unproductiveness as characteristic of soils rich in magnesia. Loew,† in 1901, in a review of the ratio between lime and magnesia in soils of different countries states: "It will be seen from this review (1) that the ratio of lime to magnesia ranges between wide limits: (2) that in the majority of cases lime predominates over magnesia; (3) that in all the instances of great fertility the soil never shows any marked excess of magnesia over lime, but, on the contrary, more lime than magnesia."

He writes also: "Lime and magnesia can exert their indispensable nutritive functions only in certain dependence upon each other. Hence a certain ratio between these two nutrients will produce the most favourable results."

May,‡ in 1901, published results of some culture experiments with oats, wheat, cowpeas and tobacco in water, sand and soil cultures, and drew the following general conclusions:—

"Magnesia in a soil in great excess over lime in a finely divided or soluble condition is noxious to the growth of plants."

Daikuhara§ in 1905 observed that on well-manured soils in which the ratio of calcium to magnesium was 0·34 to 1, the yield of naked barley was doubled by producing a ratio of 1 to 1.

Bernardini and Siniscalchi‖ in 1908, as a result of growing lupins in pot cultures, made the observation that "the injurious action of an excess of lime and the poisonous action of an excess of magnesia in a soil is not due to the absolute quantity of calcium and magnesium ions absorbed by the plant, but to the ratio in which they are absorbed."

Konovalov's¶ results, published in 1907, with wheat, lupins and oats grown in water and sand culture, do not confirm Loew's view that "there is a definite lime magnesia ratio for each plant." According to Konovalov, the yield is increased with the increase of the proportion of lime to magnesia.

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* Mayer: "Lehrbuch der Agrikulturchemie," 3rd ed., 2, 111.

† Loew: "Liming of soils from a physiological standpoint." U.S.A. Agric. Dept., Veg., Physiol. and Path. Div., Bul. 18, 1-60.

‡ May: "Experimental study of the relation of lime and magnesia to plant growth." U.S.A. Agric. Dept., Plant Indus. Bur., Bul. 1, 37-54.

§ Daikuhara: "Correction of a very unfavourable ratio of lime to magnesia in a soil for the culture of barley." Japan Imp. Cent. Agric. Expt. Stn., Bul. 1, 13-16.

‖ Bernardini and Siniscalchi: "Intorno all influenza di vari rapporti fra calce e magnesia sullo sviluppo delle piante." R. Senola Sup. Agr. Portici.

¶ Konovalov: "On the question of the different correlations between lime and magnesia in the nutritive solution." Russ. Journ. Expt. Landw. 8; 257-280.

Culture experiments with rye, maize and kidney beans were reported by Bernardini and Corso* in 1908. The nutrient solution contained the ratios of lime to magnesia (magnesia as 1), 3, 2, 1, $\frac{1}{2}$ and $\frac{1}{3}$. Rye gave the best results in the solution in which the relation of lime to magnesia equalled 1 and better results with the higher proportion than the lower; maize gave the best results with the proportion of lime to magnesia equal to 2 and better with the higher than the lower, showing that an excess of lime does less harm than an excess of magnesia.

From the results of experiments with oats, beans, rice and millet, Aso† in 1909 confirmed the observation that a certain favourable ratio of lime to magnesia exists for plant growth.

This review of the work which has been done with regard to the influence of the lime-magnesia ratio upon plant growth is admittedly incomplete, but sufficient data have been given to show that the best development of a plant depends, other things being equal, upon a certain ratio of the amounts of lime and magnesia available for absorption by plants. For cultivated plants, the optimum ratio varies between one part of lime (CaO) to one part of magnesia (MgO) and seven parts of lime to one part of magnesia, according to the variety of plant; in general, the lime must exceed the magnesia in amount.

In the soil, the relations of the lime and magnesia to plant growth are not so simple, because it is impossible to determine the actual quantities of lime and magnesia available for absorption by the plant, owing mainly to the absorptive properties of the soil by which they remove the bases from solution and hold them in a somewhat difficultly soluble form.

For the determination of the available amounts of lime and magnesia in the soil, Katayama‡ in 1902 claimed that the extraction of the fine earth $<$ 0·25 mm. with 10 per cent. hydrochloric acid afforded reliable information as to the relative amounts of lime and magnesia available for absorption by plants. This method has only recently come to my notice, and we have not had an opportunity of testing its accuracy in the case of the soils of the Great Dyke.

In an endeavour to obtain a measure of the amounts of lime and magnesia which are available for absorption by plants in the Dyke soils, I adopted Dyer's method used for the determination of available phosphoric oxide and potash in soils, viz., extraction of the fine earth $<$ 3 mm. with 1 per cent. citric acid solution at the ordinary temperature for one week.

* Bernardini and Corso: "Concerning the influence of various relations between lime and magnesia on the development of plants." Staz. Sper. Agr. Ital., 41, 191-208.

† Aso: "On the influence of the ratio of lime to magnesia upon the yield in sand culture." Tokyo Imp Univ., Agric. Col. Journ., 1, 175-180.

‡ Katayama: "On the determination of the available amounts of lime and magnesia in the soil." Bul., Agric. Col. Univ. of Tokyo, vol. vi.

Comparing field results with laboratory analyses, Dyer's method certainly appears to afford a good indication as to the relative availability of the lime and magnesia. Although one cannot justifiably be dogmatic, yet from the experience gained one is able now to predict with a fair degree of accuracy in the case of the virgin soils of the Great Dyke the returns of maize—the staple crop on the heavier soils of this territory—which are likely to be obtained.

Rocks, Soils and General Features of the Great Dyke.

The soils of the Great Dyke are red, chocolate and black loams, the black being the heavier in character and situated in the vleis, and the red and chocolate on the slopes.

Although the crop returns on many of the soils situated on the Great Dyke have been unsatisfactory, the veld in those areas with which I am familiar is covered with a rich growth of sweet grass, which affords excellent grazing for cattle, and, with its plentiful supply of good water, the country is undoubtedly excellent for stock farming.

On some of the Great Dyke soils, more particularly those derived from the norite formation, some very fair returns of maize have been obtained, and the fact that the natural herbage is so good throughout leads one to hope that crops of economic importance and improved economic methods of soil treatment will be found that will prove suitable for those soils of the Great Dyke which have been less productive in the past.

As will be appreciated from the following results of analyses of specimens of norite, enstatitite and serpentine obtained from the Great Dyke formation, the composition of the Dyke soils derived from norite are richer in lime than those which result from the weathering of serpentine and enstatitite. This feature is of particular interest, because it has enabled us to compare field returns on Dyke soils of various lime-magnesia ratios.

Composition of Great Dyke Rocks.

	Serpentine. No. 432.	Enstatitite. No. 795.	Norite. No. 1022.
	Per cent.	Per cent.	Per cent.
Loss on ignition	6·70	0·12	0·21
Insoluble matter after infusion with sodium carbonate	51·50	52·70	46·04
Ferric oxide and alumina	12·85	15·90	28·98
Lime (CaO)	1·45	2·90	14·66
Magnesia (MgO)	27·53	28·52	7·13
	Soda, etc., not determined.		

In reporting upon the geological characters of the specimens submitted to analysis, the late Mr. A. E. V. Zealley* stated as follows:—

No. 432.—The rock is an altered enstatitite.

No. 795.—A medium grained olive-green rock, made up of enstatite and felspar with a trace of mono-clinic pyroxene. The rock is better classed with felspathic enstatitites. The felspar probably is about 15 per cent. of the rock.

No. 1022.—A medium grained felspar-rich norite, consisting of about two-thirds by volume of labradorite-bytownite and one-third diopside and enstatite (together).

It will naturally be expected that norite soils, on account of their higher content of lime, will be more productive than those derived from serpentine or enstatitite, and this has undoubtedly proved to be the case.

In classifying the soils of the Great Dyke according to geological origin, one is at a disadvantage, as the Dyke formation has so far only been systematically surveyed in one region, viz., the Selukwe Mineral Belt. From the report of this survey, which was published last year by the Southern Rhodesia Geological Survey Department, it is seen that the central portion of the Dyke in that belt is represented by felspar-rich norite and the two sides by enstatitite, consequently, if this arrangement prevails generally, it will follow that the more productive soils of the Dyke will most probably be located in the middle of the intrusion.

As typical examples of the general chemical characters of the more productive and the less productive soils of the Great Dyke, the following cases are cited:—

Composition of Soils Occurring on the Great Dyke.

Analysis of air-dried fine earth (portion passing through 3 mm. sieve). Samples treated with hydrochloric acid (sp. gr. 1·12) and digested for forty-eight hours on a water bath:—

* "The Geology of the Selukwe Mineral Belt." Southern Rhodesia Geological Survey, Bul. 3.

No.	307	156 G
Nature of sample	vlei soil	vlei soil
Probable geological origin	serpentine	norite
Depth of sample	0–9 in.	0–9 in.
	Per cent.	Per cent.
Total loss on ignition	19·48	18·52
Silica and refractory silicates	61·72	57·07
Ferric oxide and alumina	15·95	21·24
Lime (CaO)	0·34	1·90
Magnesia (MgO)	2·66	0·98
Phosphoric oxide	0·037	0·026
Potash (K_2O)	0·020	0·069
Nitrogen	0·14	0·11

Soluble in 1 per cent. citric acid solution, 100 grms. fine earth extracted with 100 c.c. 1 per cent. citric acid solution for one week:—

	Per cent.	Per cent.
Phosphoric oxide	0·0088	0·0016
Potash (K_2O)	0·0044	0·0062
Lime (CaO)	0·106	0·271
Magnesia (MgO)	0·384	0·258

Ratio of lime to magnesia (lime as 1):—

Hydrochloric acid extract	1 : 7·8	1 : 0·5
1 per cent. citric acid extract	1 : 3·6	1 : 0·9

The soil from which No. 307 was taken had during the two previous years been well worked and cropped to maize. The yield of grain from first- and second-year land was, however, less than a bag (200 lbs.) per acre, and the return was so unsatisfactory that the land has since been allowed to revert to grass.

On the land from which No. 156 G was taken, a manurial trial has recently been conducted, and the check plots

(untreated), in spite of considerable loss from insect attack (cut-worms), yielded 1,002 lbs. (five bags) of maize per acre, whilst land adjoining, which received an application of ten tons of kraal manure per acre, returned an average of nine and a quarter bags of maize per acre.

Poor crop returns on many other soils similar in composition to No. 307 have been reported, and, other things being equal, the chief difference between the two soils cited above lies in the ratio of lime to magnesia, and, from a study of the field conditions, it is inferred that the low returns obtained from soils similar to No. 307 have been due chiefly to the presence of an excess of available magnesia over lime.

In the course of my official duties, samples of virgin soils from the Great Dyke are constantly being submitted for an opinion as to the suitability of the area which they represent for arable farming, consequently some factor regarding the lime-magnesia ratio has to be decided upon for the purpose of interpretation of analyses. From the limited data gathered together by correlating the composition of arable Dyke soils with the crop returns obtained therefrom, it has been observed that when the ratio of lime to magnesia soluble in 1 per cent. citric acid solution exceeds 1 : 3 (lime as 1), the tendency is to experience very poor returns of most of the common crops (maize, etc.). It must, however, be pointed out that this interpretation of the figures of analysis is not absolutely conclusive, although a considerable amount of research work on the soils of the Great Dyke has been accomplished.

The Dyke soils throughout are admittedly poorer in phosphoric oxide and potash than the best soils of this territory, and doubtless in building up their fertility the addition of phosphatic and potassic manures will be necessary, but that lack of available plant food is not the cause of the low returns from at least one pyroxenite soil occurring on the Great Dyke has been proved by the fact that an attempt to grow barley under irrigation with the aid of a liberal dressing of a complete fertiliser ended in complete failure. It is of interest to note that in the soil to which reference is made the ratio of lime to magnesia soluble in concentrated hydrochloric acid was as follows:—

Lab. No.	Depth of sample.	Lime (CaO).	Magnesia (MgO).	Ratio of Lime to Magnesia (Lime = 1).
		Per cent.	Per cent.	
424	0 – 9 in	0·167	2·60	1 : 15
425	9 – 18 in	0·080	2·17	1 : 27

From the above results of analyses it is seen that the amount of magnesia in the soil greatly exceeds that of lime.

The treatment usually recommended for soils containing an excessive amount of magnesia is the application of lime, but in this territory the cost of an adequate lime dressing, except in the neighbourhood of a lime deposit, renders this method of treatment prohibitive at the present time.

Artificial manures have been tried on several soils of the Dyke, the effects of which have been variable, and in many cases very disappointing.

The most effective and economical treatment for all types of soil on the Great Dyke which has yet been discovered has been the application of liberal dressings of kraal manure—a fact which it is interesting to compare with Davy's observation in 1814, when he stated that peat was a "proper and efficient remedy" for the injurious effect of too liberal dressings of magnesia lime.

Regarding crops which have proved the most resistant to an excess of magnesia, the following have thrived fairly well on untreated soil:—Kaffir corn (*Sorghum vulgare*), velvet beans (*Stizolobium* spp.), pearl millet (*Pennisetum spicatum*) and ground-nuts (*Arachis hypogaea*). The amount of magnesia which these crops will tolerate it is difficult to say, but it is evident that they have produced a very fair yield where maize, wheat, lucerne, clover, mangolds and boer manna have failed.

So far as the investigative work in connection with the soils of the Great Dyke has proceeded, my acknowledgments are expressed to the past and present staff of the Chemical Branch of the Rhodesian Agricultural Department—notably Mr. A. G. Holborow, F.I.C., and Mr. E. V. Flack—for valuable assistance in carrying out the analytical work. The most economical and practicable treatment of the Great Dyke soils for permanent agriculture is a problem which, unfortunately, has had to be suspended during the period of the Great War, and is one upon which much still remains to be done.

NOTE ON KIMBERLITE FROM THE BELGIAN CONGO.

By P. A. Wagner, Ing.D., B.Sc.

Read July 17, 1920.

Some thirty separate occurrences of kimberlite have so far been discovered in the Katanga division of the Belgian Congo. The majority of these are situated on the Kundelungu Plateau, but there are also several occurrences in the foothills by which the plateau is flanked on the east, and at least two occurrences on the plains between the plateau and the Luapula River. These plains have a mean elevation of between 3,200 and 3,400 feet above sea-level, while the altitude of the plateau ranges from 4,500 to well over 5,000 feet. The country rock in every instance is red felspathic Kundelungu sandstone, correlated by Studt* with the Pretoria series of the Transvaal system.

In a previous reference† to the deposits the writer distinguished between (*a*) the Eastern Kundelungu Group, that includes about twenty occurrences arranged in a curved line intersecting at an acute angle the eastern edge of the plateau, and (*b*) the Western Kundelungu Group, including twelve occurrences situated near the western edge of the plateau.

All of these occurrences, which comprise pipes, chonoliths and dykes, have by this time been thoroughly tested, and while some have been found to carry diamonds of good quality, none of them appear to be worthy of exploitation. The largest diamond found weighed 6 carats. The average weight of the stones recovered is stated to have been about one-sixth carat.

The kimberlite appears throughout to be of the basaltic variety, and we are here clearly dealing with a province of basaltic kimberlite, the precise limits of which have yet to be defined.

The pipes and dykes yield the same assemblage of minerals as the kimberlite occurrences of South Africa, and some of them are rich in nodular xenoliths of the cognate type.

Studt,‡ who published, in 1912, an interesting description of the Eastern Kundelungu Group, was the first to remark on the similarity between the kimberlite of certain of the occurrences and that of the Kimberley mines. This the writer was able to confirm by microscopic examination in the case of the "hardebank" of the Kambeli pipe,§ situated on one

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* Geol. Soc. S. Africa, 1913, pp. 44-106, Table I.

† *Cf.* "The Diamond Fields of Southern Africa," pp. 102-103.

‡ *Cf.* Studt, F. E.: "Report on Kundelungo Pipes, Tanganyika Concessions, Ltd."

§ *Loc. cit.*, p. 103.

of the tributaries of the Luchipuka River. Some time ago he received from Mr. M. Poulsen a fine specimen of comparatively fresh kimberlite from the Msipashi pipe, situated some miles to the north-east of the Kambeli pipe,* which again proved to be practically identical with the kimberlite from the lower levels of the Kimberley pipe.

It is a heavy rock of blackish-green colour, composed of a dark serpentinous ground-mass, in which are imbedded large irregular grains of olivine and ilmenite, and rounded grains of deep red pyrope bordered by dark kelyphite rinds, the minerals named being accompanied by occasional grains of enstatite and chrome-diopside and very occasional flakes of phlogopite. Thin sections of the rock show that olivine of at least two ages is present. To the earlier of these belong the megasopic grains, which are rounded or quite irregular in form, some of them evidently having been derived from the fragmentation of yet larger grains. It is probable that cognate xenocrysts, as well as true phenocrysts, are represented amongst them. They are all in an advanced state of serpentinisation, and many of them have been completely replaced by serpentine or by serpentine and calcite. The smaller olivines, without exception, have been completely replaced. The serpentine is of yellowish-green colour, and is seen under high powers of magnification to be composed of radial aggregates of minute scales and fibres having the optical properties of chrysotile. The serpentine, as already indicated, is frequently accompanied by calcite, the latter mineral having clearly developed at the expense of the former. Many of the smaller pseudomorphs exhibit a zonal structure, a core of calcite being surrounded by an outer zone of serpentine.

Large and small olivines together make up about 60 per cent. of the rock. The ilmenite occurs for the most part in irregular grains, but at the extremity of one grain crystal faces were observed. Most of the grains, which are up to 9 millimetres across, are surrounded by narrow "reaction" rims composed of small crystals of perowskite.

The pyrope occurs in rounded grains up to 5 millimetres across, encased in broad kelyphitic rinds. These exhibit a zonal structure. At their inner periphery and in direct contact with the pyrope, or separated from it by a narrow colourless selvage, is a translucent zone of pale yellowish colour composed of minute radially disposed fibres. The latter have a high refractive index and fairly high birefringence. They extinguish obliquely at angles up to 44°, and would thus appear to be composed of a mineral belonging to the family of the monoclinic pyroxenes. The minute size of the fibres renders their closer identification impossible. This zone is succeeded outward by a broad opaque zone of deep reddish-brown colour, that in turn merges into a narrow outer zone composed mainly of lustrous particles of magnetite. In some

* The situation of both pipes is shown on the map published on p. 102 of "The Diamond Fields of Southern Africa."

instances the inner fibrous zone is very narrow and discontinuous. In other instances, it itself exhibits a zonal structure, being composed of an inner zone of pale brownish-red colour and an outer zone of brownish-yellow colour.

The ground-mass of the rock consists of pale greenish-yellow serpentine crowded with small crystals and anhedrons of perowskite, ilmenite and magnetite, and enclosing large and small patches of calcite communicating with stringers of that mineral. Small crystals and anhedrons of apatite are also present. Perowskite is very abundant. It occurs in cubical crystals and rounded grains of purplish-brown colour, exhibiting anomalous birefringence. These often form wreaths about the idiomorphic ground-mass olivines. The mineral is unusually abundant in the neighbourhood of some of the larger phenocrysts of ilmenite surrounded by reaction rims of perowskite that has clearly developed at the expense of the ilmenite. This suggests that the crystals and grains of perowskite occurring in the ground-mass are also of secondary origin. The apatite is partly in the form of hexagonal prisms and partly in the form of peculiar ragged grains identical with those found in some varieties of kimberlite of the Kimberley mines. The serpentine, of which the bulk of the ground-mass is composed, again consists of minute radial aggregates of chrysotile fibres. As to the original nature of the ground-mass, there is nothing to go upon.

The kimberlite, both in its megascopic and microscopic character is, as previously indicated, almost identical with that of the Kimberley Mine, situated some 1,200 miles to the south —proof, if any were needed, of the correctness of Carvill Lewis's contention* that kimberlite is a distinctive rock type, and entitled as such to a specific designation.

CONSTITUENTS OF THE FLORA OF SOUTHERN RHODESIA.

By F. Eyles.

Read July 15, 1920.

No attempt, so far as I am aware, has yet been made to correlate the flora of Southern Rhodesia with that of the rest of Africa south of the equator or with the northern tropical region. Various botanists have from time to time published papers dealing with the local flora. These include Marloth, Swynnerton, Gibbs, Rand, Engler, Sim, Burtt-Davy and Monro.

* Geol. Mag. 1887, 3, iv, pp. 22-24; also "Papers and Notes on the Genesis and Matrix of the Diamond." London, 1897, p. 50.

In 1915 the Royal Society of South Africa published the paper in which I brought together for the first time a record of all the collections made to that date, so far as possible, though it was not quite complete, as I did not get access to the records of every collector. That paper was really a check list of Rhodesian plants, with the addition of all information then available as to distribution. Since that time our knowledge of the vegetation of Rhodesia has been considerably increased, particularly in the direction of records of distribution. Additions to our list of species have not been very great, only about five hundred new species being added in five years.

If we compare Rhodesia with the Union, we find that our conditions are, relatively speaking, uniform, for we have no such extremes of elevation and climate as are found in the western coast region, with its rainfall of from two to four inches at sea-level, or the 10,000 ft. Drakensberg, with its winter snows. Speaking generally, Southern Rhodesia belongs to the great Central African plateau, with an altitude of from 3,000 to 5,000 feet and an annual rainfall of from 15 to 40 inches. At the same time, it would be a mistake to regard our floristic conditions, as being really homogeneous, for we have mountains on the east rising from 6,000 to 7,000 feet, while there are parts of the country as low as 1,300 feet, and relatively limited areas enjoy an annual rainfall of over 60 inches.

It is hoped that we may soon be in a position to divide Rhodesia into botanical regions, and Mr. J. S. Henkel is now at work on this problem, with assistance from the Geological Survey Department and the Meteorological Branch of the Agricultural Department.

I should like here to emphasise the fact, not perhaps sufficiently recognised, that the solution of the urgent problem of getting a true knowledge of our local vegetation, its constituents and its distribution, would be immensely accelerated if some positive and active collaboration could be arranged between the geologists, the surveyors and the botanists of the country. The great practical importance of expediting such acquisition of knowledge in a country largely awaiting settlement need not be enlarged upon; suffice it to say that so long as our records of the indigenous flora of different districts remains incomplete, and often quite vague, so long will it be difficult to give safe advice as to what crops, what pasture plants, and what trees can be established in any given place, and thus the pastoral and agricultural industries will advance less rapidly than might otherwise be the case. Further, the initiation of potential industries will be delayed for lack of definite information regarding supplies of timber so essential to many of them.

At this stage it may be of interest to place on record the constituents of the flora of Southern Rhodesia so far as at present known. Such analyses of the floristic elements have been made for other regions of Africa, but, I believe, not hitherto for Rhodesia.

The predominating orders, or families, of flowering plants are as follows:—

	Number of species.	Per cent. of whole.
1. Compositae	292	10·8
2. Leguminosae	280	10·4
3. Graminae	238	9·9
4. Rubiaceae	122	4·5
5. Acanthaceae	97	3·6
6. Euphorbiaceae	97	3·6
7. Labiatae	89	3·3
8. Liliaceae	81	3·0
9. Scrophulariaceae ...	79	2·9
10. Asclepiadaceae	70	2·6
11. Cyperaceae	62	2·3
12. Malvaceae	55	2·0
13. Orchidaceae	53	1·9
14. Convolvulaceae	53	1·9
15. Combretaceae	39	1·5
16. Campanulaceae	36	1·3
17. Tiliaceae	34	1·2
18. Iridaceae	33	1·2
19. Anacardiaceae	29	1·1
20. Sterculiaceae	28	1·0

The chief families falling below the 1 per cent. mark are the following, with the number of species of each:—

Verbenaceae, 28; Polygonaceae, 23; Polygalaceae, 22; Vitaceae, 21; Loranthaceae, 20; Apocynaceae, 20; Comelliniaceae, Amaryllidaceae, Crassulaceae and Lythaceae, 19 each; Moraceae, Loganiaceae, Solanaceae and Cucurbitaceae, 18 each; Boraginaceae, Amaranthaceae and Pedaliaceae, 17 each; and Capparidaceae and Gentianaceae, with 16 species of each.

There remain 103 other orders, represented by less than 16 species each, some having only one single species for the whole order.

In 1915, 2,227 Phanerogams were recorded for the country, while the total at present known is 2,690, an increase of 463 species.

The partial analysis here given shows that 70 per cent. of the whole flora is comprised within 20 families, the remaining 30 per cent. being spread over no less than 122 families. The predominance of a few families comes out even more clearly if we speak in round numbers and say that 3 families by themselves (Compositae, Leguminosae and Graminae, about 10 per cent. each) contain over 30 per cent. of the flora; that the next 40 per cent. is covered by 17 families; and that the remaining 122 families include only 30 per cent. of the flora. Gymnosperms are represented by only 2 species, and the proportion of monocotyledons and dicotyledons is as 1 : 3·84.

As I have not had access to the latest literature on the subject, I cannot attempt to institute comparisons between the flora of Southern Rhodesia and that of other better-known regions, but I think there can be little doubt that our southern and western districts will be found to have close affinity with the northern parts of the Union, and particularly with the region sometimes spoken of as the Kalahari, while our northern one will be found closely related to the Central African flora, and the eastern coast belt nearly akin to the south-east coast region of the Union.

The high position of the Rubiaceae, which may be marked fourth on the list, seems unusual, though it is probable this will be found to be a feature of the Central African flora north of the Zambesi. As far as I am aware, the position of the next three families is also unusually high in the list, that is the Acanthaceae, Euphorbiaceae and Labiatae. I do not think they occupy such an important place in any of the regions to the south. Scrophulariaceae is unexpectedly low in position (ninth) and Liliaceae much less important than in most of South Africa. Very little work has been done on the Cyperaceae, and I have little doubt that when they are systematically examined, they will climb up the ladder, on which now they occupy the eleventh rung. The Gramineae, although now standing in the third place, are really not well known, and may be found to assume an even greater importance when further studied.

I have omitted all reference to Cryptogams, as there are so few workers in this branch, and it is perhaps better to keep them distinct from Phanerogams in tabular comparisons of this kind.

Although progress in knowledge of the Rhodesian flora has been slow during the last five years, I am confident that we have now reached a stage when rapid advance may be expected. Interest in the subject is awakening as its importance becomes more and more realised, and I am glad to say that the number of locally resident students and collectors is to-day greater than ever before.

I regret that I have not been able, for reasons given, to work out the relationship of the Rhodesian flora with that of adjacent territories, but I hope that the analysis of its constituents now placed on record will serve as a definite landmark from which we can go forward with investigation and research, and that it may be of assistance to all workers in this field.

ADDITIONAL HOST-PLANTS OF *LORANTHACEAE* OCCURRING AROUND DURBAN.

By Paul A. van der Bijl, M.A., D.Sc., F.L.S.

Read July 15, 1920.

At the last meeting I submitted a list of some of the host-plants of the *Loranthaceae* occurring around Durban.† Since then every endeavour has been made to obtain further host-plants of these parasites. The additions in the list now submitted make the host-plants fairly complete for the locality studied, and the two lists combined are the most complete index of host-plants yet available for South African *Loranthaceae*. It would be interesting to prepare similar lists for other localities and thus ultimately include all the species of *Loranthaceae* occurring in South Africa. The introduced plants in the present list are again marked with an asterisk (*):—

Loranthus Dregei, E. and Z.

Acacia hirtella, Willd.
Acalypha glabrata, Thb.
Antidesma venosum, Tul.
Apodytes dimidiata, E. M.
*Araucaria excelsa, R. Br.
Baphia racemosa, Hochst.
Celastrus nemorosus, E. and Z.
Commiphora Harveyi, Engl.
Brachylaena discolor, D. C.
Bridelia micrantha, Planch.
Burchellia capensis, R. Br.
*Eriobotrya japonica, Lindl.
*Eucalyptus, sp
Ficus natalensis, Hochst.
*Gleditschia japonica, Miq.
*Heterophragma adenophyllum, Seem.
*Nephelium longaan, Cambess.
*Nerium oleandra, Linn.
Pavetta lanceolata, Eck.
*Phyllanthron comorense, D. C.
Plectronia spinosa, Klotzsch.
Popowia caffra, H. and S.
*Populus sp.
*Psidium Guayava, Linn
*Quercus pedunculata, Ehrh.
Rawsonia lucida, Harv.
Rhus natalensis, Bernh.
Rhus villosa, Linn.
Schmidelia africana, D. C.
*Spathodea speciosa, Brogn.
Strychnos Henningsii, Gilg.
Trema bracteolata, Bl.
Zizyphus mucronata, Willd.

Loranthus Kraussianus, Meisn. (*Vide* previous list.)

Chaetachme aristata, Planch.
Grewia occidentalis, Linn.
Gardenia Thunbergii, Linn.
Toddalia lanceolata, Lam.

† South African Journal of Science, vol. xvi., p. 344.

Loranthus Natalitius, Meisn. ("Flora Capensis," vol. v, sect. ii, pt. i, p. 114. "Natal Plants," vol. iv, plate 374.) This species is not mentioned in the first list.

Acacia caffra, Willd. (At Malvern and Pinetown, Natal.)
Acacia mollissima. (At Malvern, Natal.)
Citrus aurantium, Linn. (At Malvern, Natal.)

Loranthus quinquenervis, Hochst. (Additions to previous list.)

Baphia racemosa, Hochst.
Capparis corymbifera, E. M.
Celastrus cordata, E. M.
Eugenia cordata, Laws.
Grewia occidentalis, Linn.
Maba natalensis, Harv.
Mimusops caffra, E. M.
Plectronia spinosa, Kl.
Rawsonia lucida, Harv.
Trema bracteolata, Bl.
Viscum obovatum, Harv. Here we have the interesting occurrence of one mistletoe growing on another. The host of the *Viscum* here was *Maba natalensis*.

Viscum obovatum, Harv. (Additions to previous list.)

Grewia occidentalis, Linn.
Ochna atropurpurea, D.C. var. Natalatia.
Maba natalensis, Harv.

Viscum obscurum, Thb. ("Flora Capensis," vol. v, sect. ii, pt. i, p. 125.)

Myrsine melanophloes, R. Br. (At Krantzkloof, Natal.)

The data quoted above at once indicate that *Loranthus Dregei* is the commonest "mistletoe" here and that it has adapted itself to the largest number of introduced plants, including some which belong to natural families not represented in the South African flora.

NOTE ON THE *CRASSULACEAE* FOUND IN RHODESIA.

By S. Schonland, M.A., Ph.D.,
Professor of Botany, Rhodes University College, Grahamstown.

Read July 17, 1920.

In Oliver's "Flora of Tropical Africa," vol. ii (1871), Britten enumerates six species of *Tillaea*, three of *Crassula*, one of *Bryophyllum*, eighteen of *Kalanchoe*, three of *Cotyledon*, two of *Sedum*, three of *Sempervivum*. None of the localities mentioned by him appear to be in Rhodesia. The number of new species described since 1871 has not been inconsiderable, though, broadly speaking, Tropical Africa is poor

in *Crassulaceae*. To give only one instance: In the whole of Tropical Africa only 21 species of *Crassula* (including *Tillaea*) are known to me, against about 180 in Temperate South Africa. Tropical Africa and Madagascar are the headquarters of the genus *Kalanchoe* (in which R. Hamet has sunk the genus *Bryophyllum*), Asia, Oceania and America possessing only a few rare species. *Semperrivum* and *Sedum* have evidently penetrated from the north, while the distribution of the species of *Crassula* and *Cotyledon* is favourable to the view that the genus has spread into Tropical Africa from Temperate South Africa. It will be seen from the subjoined list that, judging by our present knowledge, the number of *Crassulaceae* in Rhodesia is very small and reflects the general distribution. Species of *Bryophyllum* (now placed under *Kalanchoe*), *Sedum* and *Semperrivum* are absent. *Cotyledon* is very poorly represented. There is nothing in the configuration of the country, nor in the climate, that, as far as we can judge, is in any way a hindrance to the growth of numerous *Crassulaceae*, and, as there is an almost complete absence of endemism, we may be allowed to conclude that at all events the *Crassulas* have reached the country at a comparatively recent period.

Eyles, in *Trans. Roy. Soc. S.A.*, vol. v (1916), lists from Southern Rhodesia seven species of *Kalanchoe* and four species of *Crassula*. Unfortunately, they do not seem to have been submitted to specialists. *Kalanchoe crenata* Haw., which he mentions, is a synonym of *K. laciniata* DC.; *K. pilosa* Bak. and K. *glandulosa* Hochst. are synonyms of *K. lanceolata* H. Pers. *Crassula silvatica* Licht., which he enumerates as *Crassula sarcolipes* Harv., is not likely to occur in Rhodesia. I venture to suggest that it is the same species which is mentioned below as *Cr. furcata* Schonl. Both are pubescent and have obovate leaves, but there are differences in floral structure. *Tillaea pharnaceoides* Hochst., though often quoted as a synonym of *Crassula campestris* (E. et Z.) Harv., is better kept separate. *Cr. nivalis* (E. et Z.) Harv. is not likely to occur in Rhodesia. Galpin 7369, on which Eyles' record is based, was collected at Oxton, Whittlesea, Cape Colony, and not at the Victoria Falls.

PROVISIONAL LIST OF *Crassulaceae* FOUND IN RHODESIA.

Cotyledon glandulosa N.E.Br., in *Kew Bulletin*, 1913, p. 300, Northern Rhodesia, without locality, G. Simpson-Hayward.

C. Wickensii Schonl., without locality. Foliis latis obovatis basi cuneatis, Teague, 169. Also found in Transvaal, the home of the type.

Kalanchoe laciniata C. H. Pers. (*K. crenata* Haw.), Victoria Falls (teste Eyles).

K. lanceolata H. Pers. (*K. glandulosa* Hochst., *K. pilosa* Bak.), Livingstone, north bank of Zambesi, Rogers 7443, 5235, 5130, 5235.

K. Pentheri Schl. (= *K. glandulosa* Hochst., var. *tomentosa* Keissl.), Bulawayo, Pole Evans 3279. Under *K. glandulosa*, Eyles mentions the variety *rhodesica* Bak. f. (*Journ. Bot.*, 1899, p. 434), from Salisbury, Umtali and Gwelo. This, judging from the description, seems to be *K. Pentheri*.

K. paniculata Harv., Bulawayo and Victoria Falls (teste Eyles).

K. velutina Welw. (*K. Kirkii* N.E.Br.), Zimbabwe ruins, A. M. Whitman.

K. rotundifolia Harv., Bulawayo, Pole Evans 2278: Bulawayo, Matopos, Victoria, Odzani River and Umtali (teste Eyles).

K. thyrsiflora Harv., Bulawayo (teste Eyles).

K. n.sp. (entered in Herb. Albany Museum as *K. Victoriae* Schonl. Ms. aff. *K. Quartinianae*), neighbourhood of Victoria Falls, Rogers.

K. sp., Victoria Falls, Rogers 5236 (flowers too young for determination).

K. Baumii Engl. et Gilg (*K. prasina* N.E.Br.), recorded by Hamet from Zambesia and Nyassaland.

Crassula n.sp. (entered as *C. furcata* Schonl. Ms. in Herb. Albany Museum), Matopos, Rogers 7927; Palm Grove, Victoria Falls, Rogers 5058. This, as mentioned above, is probably the plant which Eyles quotes as *Cr. sarcolipes* Harv. It was found at Victoria. It was also collected by Rogers in the Pietersburg District (Transvaal).

C. campestris (E. et Z.) Harv., Matopos (teste Eyles).

C. transvaalensis O.K. (*Cr. subulata* Harv., *Thisantha subulata* Hook.), Victoria (teste Eyles).

C. abyssinica Rich. var., Bulawayo, Rogers 13711. This agrees fairly well with the description of *C. similis* Bak. f. (Bull. de l'herb. Boiss. t. 3, 1903, p. 814), which was found by Rehmann in the Houtbosch (Transvaal).

C. argyrophylla Diels., District Makoni (4800-5300), Eyles 811 in Herb., Rogers. This is a common Transvaal plant. Odzani River Valley, Dist. Manica, Div. Umtali, A. J. Teague, 255; Ibid. Teague, 240 (a new species?).

RIPENING OF SEED IN *GNETUM GNEMON* AND *GNETUM AFRICANUM*.

By Mary G. Thoday,
Late Fellow of Newnham College, Cambridge, and late Hon. Research Fellow of Manchester University.

With Two Text Figures.

Read July 17, 1920.

This paper is a continuation of previous work* on various species of Gnetum, describing the series of changes in the seed coats during the development of the seed.

The young seed has three coverings, all of which are free, the innermost projecting upwards as the micropylar tube. In the largest seeds of Gnetum yet described—*G. gnemon* by Miss Berridge and *G. africanum* by myself—the tip of the micropylar tube enlarges and forms a stopper, which becomes adherent to the middle covering and which has its lumen closed so that no foreign substance can enter either the micropylar tube or the chink between it and the middle covering after pollination.

In the seeds of *G. gnemon* now described, three centimetres long, remarkable later changes occur which would make the morphology of the mature seed impossible to understand were its earlier stages not known—for example, if it were only known as a mature fossilised seed.

Young Ovule.

Fig. 1 is a diagrammatic view of a young ovule of *G. gnemon*, 3 mm. long, in which closure of the micropyle

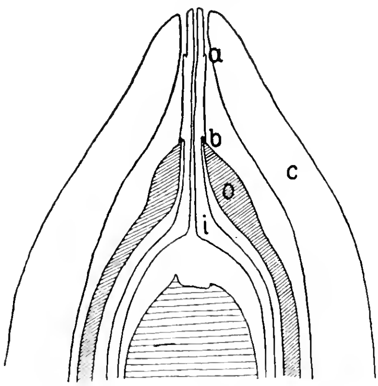

Fig. 1.—Upper portion of young seed (3 mm. long) of *G. gnemon*.

* Thoday, 1911.

is just beginning. *c* is the outer covering, *o* is the middle covering, *i* is the inner covering, terminating in the freely projecting micropylar tube. *a* and *b* are the upper and lower edges of the thickened out-growing portion of the wall of the tube. The lumen of the tube is already narrowing, though it is still open throughout. Into the lower edge of the thickened portion at *b* fits the tip of the middle covering.

INTERMEDIATE STAGES.

The next stages in the growth and closure of the micropylar tube and the development of the outer coats have already been described.*

MATURE SEED.

Fig. 2 is drawn from a mature seed, 3 cm. long, and shows the thickened portion of the micropylar tube now developed into a "stopper," fused on to the outer covering. Its lumen is now obliterated. The outer covering during ripening has carried up the stopper (*s*), dragging it away from the middle covering, and in the process the lower portion of the micropylar tube has been broken across at its weakest point above the tip of the middle covering and below the stopper. The micropylar tube is thus seen in Fig. 2 divided into two parts, the "stopper" (*s*) filling up the tip of the outer covering and adhering to it, and the "beak," or broken lower portion (*b*), which projects just above the top of the middle covering. The projecting beak is formed of hardened closing tissue and its surface is rough, where it has been dragged out from the gap *g* in the stopper. It is continuous downwards with the parenchymatous basal portion of the innermost covering. It will be seen that there is now a considerable distance between the stopper and the beak, and if the mature seed only were known, it would not be obvious that they were part of the same structure.

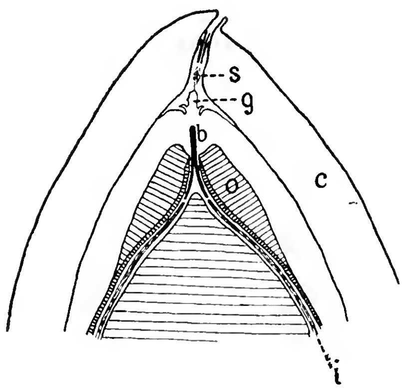

Fig. 2.—Upper portion of mature seed (3 cm long) of *G. gnemon*.

* Berridge, 1911, Thoday, 1911.

Conclusions.

The mature structure of the seed is of interest ontogenetically as a method of closing the pollinated ovule of a gymnosperm. Further, it is of importance in connection with the comparison made in former papers* between the seeds of the Gnetales and those of the Bennettitales. I do not wish to draw any conclusions as to affinity, but it seems at least possible that these remarkable growth changes in the Gnetums may help us to understand these fossil seeds, and it is conceivable that the different arrangements in the various species of Cycadeoidea and Bennettites may be due to the varying stages of maturity at which the seeds had arrived.

The simple seed of *Williamsonia Scotica*† may be compared with the young seed of Gnetum.

In the mature seeds of *Cycadeoidea turrita* and *C. Dartoni*‡ the micropylar tube has been regarded as part of the integument, but there is a break above the shoulders of the seed, beyond which the micropylar tube continues as a separate organ, filled with thin-walled tissue as in Gnetum. There is no nucellar beak figured or described in these seeds.

In *Bennettites Morierei*§ the upper portion of the micropylar tube is also filled with closing tissue, and below is a freely projecting nucellar beak, which corresponds in position and appearance with the freely projecting beak-like base of the micropylar tube in *G. gnemon*. The space within this beak-like base corresponds with Lignier's so-called pollen chamber, and the small lysigenous space described by him at the apex of the nucellus and seen to contain pollen grains corresponds in position to the pollen chamber in *G. gnemon*. Lignier interpreted what he regarded as the single integument to be a structure continuous with the micropylar tube. But there is no detailed resemblance between their respective cell organisations. It may well be that the "micropylar tube" in his description represents a stopper fastened as in *G. gnemon* to the top of the outer integument, while the projecting beak is really the broken base of the micropylar tube.

If this be the correct interpretation of *B. Morierei*, it would bring the conflicting accounts of the various genera into line with one another, while at the same time providing a parallel with Gnetum, which is at least suggestive of common ancestry.

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* Berridge, 1911; Sykes, 1912; Thoday, 1911; Wieland, 1916.

† Seward, 1912.

‡ Wieland, 1912 (Figs. 6 and 11) and 1916 (p. 133).

§ Lignier, 1894.

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A NOTE ON *DASYCHIRA EXTORTA* AND ITS LEPIDOPTEROUS PARASITE.

By C. P. VAN DER MERWE.
Government Entomologist, Durban.

Read July 15, 1920.

The caterpillars of *Dasychira extorta* have been found in Durban to feed on the foliage of the native fig tree (*Ficus natalensis*). They feed at night, and in the daytime rest in clusters on the tree trunks. Apparently they always return to their particular resting places, which become marked by their cast skins and the suspended cocoons of hymenopterous parasites.

On most of the Dasychira caterpillars tiny lepidopterous larvae about 2 mm. long can be seen, clinging to the hairs or resting close against the body of the caterpillar. As many as six larvae have been found on one caterpillar. In the breeding cages it has been observed that the larvae leave the dead caterpillars and seek living ones. The eggs from which these larvae are hatched have been found on the cast skins close by the clusters of caterpillars on the tree trunks.

Last year (1919) the Dasychira caterpillars were observed on the trees during May, and during June they were found to leave the trees, and crawl away in search of suitable hiding places to spin their cocoons, which places they usually find in crevices and corners, behind stones, on walls, under eaves, etc.

The cocoons in which they pupate are composed of four distinct layers, each of which represents a complete structure or cocoon. The outermost, or first spun, is thick and tough, and within it the second and third are thinner and softer. The innermost, or last spun, is the thinnest and softest of all. These envelopes are composed of silk and the hairs of the caterpillar. There is a funnel-shaped opening which provides for the escape of the moth. This is so constructed that some of the caterpillar's enemies are probably kept out. When the cocoon is complete, the small larvae may be found either on the caterpillar or between the cocoons; but as they can make their way through the meshes of the inner cocoons, it would not matter much whether they were enclosed or shut out by the caterpillar.

After about a week the caterpillar exudes an oily liquid, and this has been found to kill some of the small larvae which were confined, perhaps too closely, with the caterpillars.

Caterpillars and parasites may live together a long time without anything happening, and many of the latter die without having injured their host. After two and a half months to more than five months from the time the cocoon was spun, the larva may be found attacking its host. What the stimulus is which causes it to start feeding has not been ascertained. If a larva is put with a caterpillar after it has begun feeding on another, it will attack the fresh host, and if a larva which appears not inclined to start feeding on its host is removed and placed on a caterpillar already injured by another larva, it will begin to feed on it, too. Feeding starts sometimes before, sometimes after, the caterpillar has pupated. The parasite larva is full-grown when it is about 25 mm. long. It is possible that the parasite larvae are repelled by the oily excretion of the caterpillars, and can only attack them when this oil is insufficient or has become dissipated.

Some larvae seem to come to maturity fairly soon, and to find one caterpillar enough, but others feed more slowly, and the caterpillar may dry out before they have finished it. They will then leave it and look for a fresh supply of food. They make their way into other cocoons, and if they find there smaller larvae of their own species present, the evidence points to these being also devoured. They sometimes eat the head of the caterpillar and also pupal shells. The larval stage of the parasite has been found to vary from about six months to more than a year, and the pupal stage from 18 to 30 days. The parasite emerged from January to May. The Dasychira moths emerged mostly during March, but some were out as early as the beginning of December. Their pupal stage varied from 14 to 23 days.

The moth of the parasitic larva has been submitted to Mr. Janse for determination, who found it to be an apparently undescribed species, belonging to the Phycitinae.

BIRDS AND INSECTS IN BUSHMAN FOLK-LORE.

By D. F. Bleek.

Read July 15, 1920.

May I ask the help of the members of the South African Association for the Advancement of Science in identifying various birds, beasts, insects, etc., playing a part in Bushman folk-lore? The Bushmen who told the tales came from the Prieska and Kenhard Districts, and from the Katkop Hills in Calvinia. They could speak a little Dutch, and sometimes gave a Dutch name, but often mispronounced the same, so that anyone not very proficient in the Taal would be likely to write it down incorrectly. Often the men did not know the Dutch word at all, and as in the Cape Peninsula much of the up-country fauna and flora is absent, they could not point out the bird or beast meant, but only describe it.

One story tells of the doings of the *!kwai-!kwai*, a bird which came to the children and carried them off in a net in order to roast them. The Mantis came to the rescue, and told the children to call loudly that their mothers might hear. Then when the *!kwai-!kwai* was just about to roast them, he instructed them how to catch hold of their persecutor and put him on the hot stones instead, "for he is only a bird." The narrator said this was a black bird with a white bill, about the size of a duiker he had seen at the breakwater. What similar bird lives in the northern colony?

Another bird, the *!kain-!kain*, comes and stabs young girls to death and wets its beak in their blood. The Mantis has again to save them and teach them to stab the bird instead. This bird is described as having a red bill and red legs, a black back and breast. Its size is not mentioned.

I do not think the behaviour of these birds has any particular reference to their present habits, though possibly to their colouring. All these things happened long ago, when they were people, men of the early race.

A very small bird, the *kainyatana*, was carried off by the ostrich, who wished him to marry her daughter, the "yolk," because he was also yellow like the yolk. This bird is common in Bushmanland, and is sometimes seen at the Cape. The head and front part of the body are yellow.

In another tale we hear how the Mantis digs in the ground with his digging stick for the cells of a kind of wild bee, not the common kind. These cells of sweet food he eats and gives to his pet springbok to eat. This wild bee was said to be called the "blennenflij" by the Dutch. Does anyone know this insect?

On another occasion the Mantis went to hunt, and saw a little bird hovering in the air. Then it dropped to the ground and went into an ant-heap. While the Mantis stood gazing it popped out of another ant-heap, with its kaross full of ants' larvae, called "Bushman rice." Then the Mantis went up to it and begged it to show him how to get Bushman rice so easily, for his hands were sore with digging it out with a stick. The little bird showed him how it was done, but the Mantis was ungrateful and soon got into trouble. This little bird, the *konotuïten*, is black, with white feathers on its shoulders.

This Bushman rice was a great feature in a Bushman bill of fare. So also was a similar food, the *!haken*, of which they told us that it was like Bushman rice, its larvae were like those of the Bushman rice. Of what insect can it be the larvae? They seem always to have sifted this *!haken* as soon as it was dug, and to have put any part on which a certain dark-coloured fungus like a beacon grew into a separate little bag, which was kept for the old people, who evidently thought it a dainty, and presented it to their friends on a dish made of an ostrich's breast-bone.

Among the many adventures of the Mantis, we hear of him burning the bush shelters in which wild cats live, in order to kill the cats and get fine skins for his kaross. Now, do wild cats live in bush shelters, or even in bushes? Is this myth based on natural history, or is it in direct contradiction of it?

In preparing a little book of folk-lore from manuscripts of my father and my aunt, who collected much Bushman lore in the 'seventies and 'eighties, I am held up by my inability to translate these names or answer these questions, and I have hopes that from your Association helpful information may come. Such information may be sent to the authoress at Charlton House, Mowbray, C.P.

A TACHINID PARASITE OF THE HONEY BEE.

By S. H. Skaife, M.A., M.Sc.

With Six Text Figures.

Read July 15, 1920.

In vol. xv of the "Annals of the South African Museum" (1916), Dr. J. Villeneuve described a new genus and species of Tachino-Oestrid fly from South Africa, which he named *Rondanioestrus apivorus*. The genus and species was founded on a single specimen, a male, from Port Elizabeth, "alleged to have been bred from a honey bee (F. W. Fitzsimmons)." Dr. Villeneuve adds a note that "this biological indication is the more interesting that nothing was hitherto known of the habits of the Tachino-Oestrid Diptera." But this fly seems to have been known since 1903, for Mr. A. J. Attridge, of Capetown, has kindly pointed out to me a passage in Sladen's "Queen-Rearing in England," which reads as follows:—

"Parasite in Bee's Abdomen.—Mr. A. C. Sewell, of Durban, Natal, sent to the "Beekeepers' Record" in February, 1903, a remarkable looking fly-maggot which had been squeezed out of the abdomen of a living worker honey bee, and which was forwarded to me for inspection. Later on, Mr. Sewell found a second specimen of this larva on the glass of his solar wax extractor, and from this he succeeded in breeding the perfect fly. Both the fly and its pupa-case were forwarded to me, and I took all three specimens to Mr. Austen, of the British Museum, who kindly gave me some interesting information about them. There seems to be no reason to doubt that both larva and fly are the same species. The fly resembles in size and appearance the common house fly, *Musca domestica*, and belongs to the same family, *Muscidae*, which is a very extensive one, and comprises nearly half the known species of flies. It also belongs to the sub-family *Tachininae*, which, too, is largely represented in England. The *Tachininae* are all (in the larval stage) parasitic in the bodies of insects, chiefly caterpillars. Although there seem to be few records of their occupying the bodies of perfect insects, such cases no doubt frequently occur. So far as I know, this is the first recorded case of an insect larva having been observed to inhabit the honey bee. The two posterior stigmata (breathing orifices) of the larva are developed into two exceptionally large and curious hard, black plates."

Mr. Attridge also states in a letter to me that he himself found a maggot in a number of bees at Sea Point about seventeen years ago, and that these parasitic maggots were also reported last winter from Groot Drakenstein. From Sladen's description, quoted above, there is little doubt but that the fly found at Durban is the same species as that recorded from Port Elizabeth, and it is very probable that the larvae found by Mr. Attridge at the Cape are also of the same species.

On 5th May, 1919, one of the students at the Cedara School of Agriculture (H. Whittaker) brought to me a Dipterous larva, which, he said, he had seen leave the body

of a bee which had fallen dead at his feet. This larva was placed in a specimen tube, and pupated in the course of an hour. The adult fly emerged on the 3rd July. On 11th November, another student (J. Lamb) found a similar maggot in one of the hives at Cedara. This larva pupated shortly after it was found, and the adult emerged on 23rd December. The fly proved to be identical with the one reared six months previously, and was determined by Dr. Peringuey as *Rondaniocestrus apivorus*, Villen.

Villeneuve's note that "nothing was previously known of the habits of the Tachino-Oestrid Diptera" made me decide to study the life-history of this interesting fly, and the results of observations made at Cedara during the past nine months are embodied in this paper.

The adult fly is found haunting the hives from December to February, and again from May to July. It looks very much like a squat house fly, dark grey in colour, as it rests on the alighting board or just above the entrance to the hive (Fig. 1). At Cedara one or two of these flies can generally

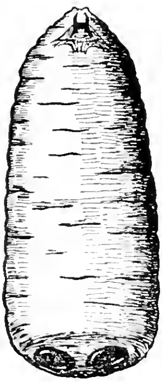
Fig 2.
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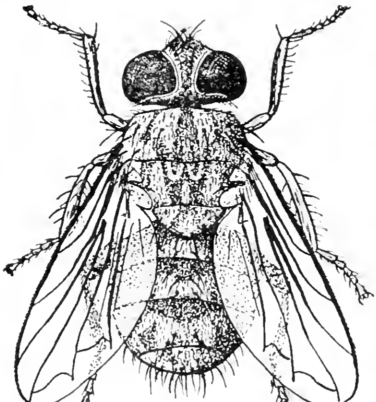
Fig 1.

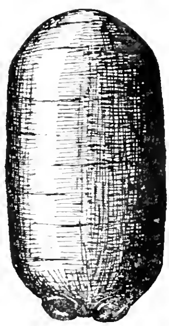
Fig 3

Fig. 1.—*Rondaniocestrus apivorus* Villeneuve. Adult female.
Fig. 2.—*Rondaniocestrus apivorus*. Mature larva.
Fig. 3.—*Rondaniocestrus apivorus*. Puparium.

be found frequenting each hive during the months mentioned above, especially during January and June. The flies captured in the apiary are all females—in fact, the only males I have come across I have bred out myself in the laboratory. I have been unable to discover what these insects feed on in the adult state. Some specimens kept in cages made no attempt to feed on the honey and water offered to them, and died in the course of two or three days.

If a newly-emerged female is dissected, her ovaries are found to consist of two large white spherical masses of eggs showing no semblance of ovarian tubes. Each ovary measures about 3 mm. by 2 mm. and contains three to four hundred

cigar-shaped eggs, each one of which measures ·56 mm. by ·14 mm. (Fig. 4). At the junction of the short oviducts there are three conspicuous brown spermathecae, spherical in shape, and measuring about ·2 mm. in diameter. From this point a long, slender, much-coiled tube, 50 to 60 mm. in length and with muscular walls, leads to the ovipositor. There is one pair of accessory glands, which join the oviducts at the point where they fuse.

If one of the females haunting the hives be caught and dissected, a very different condition of the reproductive organs is found. The ovaries have quite disappeared, and the long, slender tube mentioned above is found to be crowded

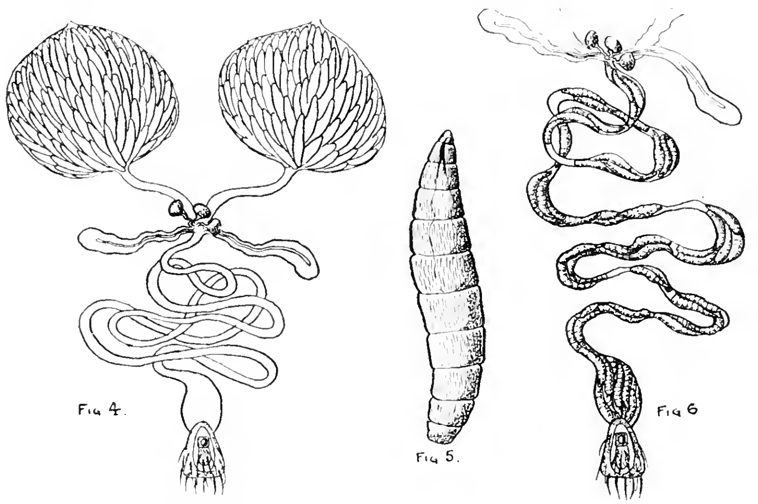

Fig. 4.—*Rondaniocestrus apivorus.* Reproductive organs of unfertilised female.

Fig. 5.—*Rondaniocestrus apivorus.* Newly-hatched larva.

Fig. 6.—*Rondaniocestrus apivorus.* Reproductive organs of fertilised female.

with a large number of living larvae. In some females these newly-hatched larvae are so numerous that the oviduct bulges with them irregularly throughout its length, but in others (individuals that are almost spent) comparatively few larvae are found crowded together in the vagina (Fig. 6).

If one of the females resting on a hive be watched, it will be found that after resting for a few moments she rises on the wing and hovers just above the entrance with her head pointing towards the hive. In a few seconds she commences to swoop down on the incoming bees, lightly touching each one with the tip of her abdomen. The movement is very swift, and difficult to follow. The bees are very lightly touched, for only a few of them are thrown off their balance and fall on the alighting board. The majority of them fly straight into the hive as though nothing had happened. After

striking at a number of bees (up to a dozen or more) in this way, the fly settles down for a few moments rest, after which the above tactics are repeated once more.

Each time the fly touches one of the incoming worker bees she deposits a tiny larva on its body, and this larva burrows into the abdomen of its host through the intersegmental membranes. It is difficult to catch one of the stricken bees before it enters the hive, although it can be done at the expense of much patience and several stings. The manner in which the larva enters its host can be easily observed, however, by catching one of the females and a few bees and stupefying them with chloroform. The larvae can then be dissected out of the fly and placed on the bees' bodies by means of a damp camel-hair brush. The manner in which these larvae crawl about until they reach the joints between the abdominal segments can then be readily observed with a strong lens. At this stage the larvae are half a millimetre in length, and marked with numerous broken, shallow, longitudinal creases in the chitin (Fig. 5).

The parasite feeds on the abdominal tissues of its host, but seems to leave the alimentary canal and the nervous system to the last, for I have caught bees flying vigorously around the hives which on dissection were found to contain full-grown larvae occupying almost the whole of the abdomen. On no occasion have I found these parasites in the head or thorax of their hosts. The death of a parasitised bee is very sudden. Twice I have been fortunate enough to see a flying bee fall suddenly to the ground and die in a few minutes, and about ten minutes afterwards a full-grown maggot has forced its way out between the abdominal segments of the dead body of its host.

The larva when fully grown measures about eight millimetres in length, and can be easily recognised by the two large circular black spiracular plates at the posterior end of its body (Fig. 2). No orifices are discernible in these plates even under the microscope after boiling in potash. The buccal armature is shown as viewed from above in Fig. 2, and from the side in Fig. 5.

After leaving the dead body of the host, the larva may either burrow into the ground or it may seek out a sheltered spot beneath dead leaves, stones, etc. A number of them were caught by the simple expedient of placing pieces of board on the ground around the hives. The larvae that had left the bees that had died in or near the hives crawled under these boards to pupate. The puparium is formed very rapidly, within half an hour of leaving the host, and the dark brown colour is assumed within an hour. They are oval in shape, blackish-brown in colour, about six millimetres in length, and may be recognised by the conspicuous circular spiracular plates.

I have found these puparia buried about an inch beneath the soil where the ground was loose, beneath dead leaves, under stones, under the legs supporting the hives, and also

lodged in crevices in the bottom boards of the hives themselves. The pupal stage lasts seven to eight weeks in summer and eight to ten weeks in winter.

It is practically impossible to determine accurately the length of the larval stage, as bees taken from the hives and kept in cages die in the course of a few days. There are two generations a year, the pupal stage lasts some two months, the adult probably lives for three or four weeks, hence the larval stage should last for about three months. The adult fly attacks the incoming bees indiscriminately, therefore many of the larvae must be deposited on old bees, which die before the larvae have time to reach maturity.

As a pest, *R. apivorus* cannot be regarded as serious. Only adult worker bees (and probably drones as well) are attacked, and, as many of these are old and worn-out when attacked, their loss is negligible. The younger bees that are parasitised seem to work just as well as normal bees almost up to the time of their death. It is difficult to form a correct estimate as to the number of bees destroyed by this parasite, as many of them must die whilst in the field, and are thus lost sight of. Out of one hundred bees caught at the entrance of one of the hives, only three were found to harbour the parasite. Besides the incoming foraging bees, the fly attacks the young bees during their midday play-spell in front of the hive, and it is probable that it is only the larvae deposited on these young bees that have any chance of reaching maturity.

The simplest remedy for this pest is to go round the apiary at midday and kill the flies with a fly-swatter as they rest on the front of the hives. They are sluggish and easily killed, but it is advisable to wear a veil whilst engaged in this work, as the bees strongly object to the flapping of a swatter against the hives. A number of the puparia can be trapped and destroyed by leaving pieces of board lying on the ground around the hives. These should be examined periodically from November to January and again from April to June.

Summary.

1. *Rondaniooestrus apivorus* parasitises adult bees, and seems to be widely spread in South Africa.

2. The eggs are hatched within the body of the female.

3. She haunts the entrances of the hives and deposits living maggots on the incoming bees.

4. The young larva burrows into the abdomen of its host and feeds on the abdominal tissues.

5. In about three months the larva is mature and the bee dies.

6. Pupation takes place in loose soil, beneath refuse, or in the crevices of the hive.

7. The pupal stage extends over about two months.

8. Killing the adult flies around the hives and destroying the puparia are the only remedies.

AGRICULTURAL ECONOMICS.—COST OF PRODUCTION OF MAIZE.

By R. A. Lehfeldt, D.Sc.,

Professor of Economics, University College, Johannesburg.

Read July 17, 1920.

Farmers are, naturally enough, averse from keeping accounts, so that if one is to advocate the somewhat complicated business of cost-accounting for farmers, it must be on solid grounds of advantage.

Cost-accounting consists in finding out, as precisely as may be, what it has cost to turn out some particular product. It is a system which has come to be recognised as indispensable in manufacturing. A manufacturer, turning out a number of different products, may be making a profit on his business as a whole. Unless, however, his accountant can tell him how much each article has cost, he is not sure but that he may be losing on some of them; he cannot tell in what directions it would be most profitable to extend his business; in fact, he has no proper guide to policy—he is working in the dark.

The same is true of farming. The choice of crops to grow is usually a matter of tradition or of guessing. The only scientific guide to investment is to find out how much each crop costs to produce, and compare with the selling price. Not only is this important to the individual farmer, but it is desirable as a matter of public policy, for the wildest and most contradictory statements are current as to the cost of producing important foodstuffs, and if Government is to interfere, and regulate prices, it must do so with proper knowledge.

Cost accounts in farming are subject to certain special difficulties. Of these the most obvious is the variability of the yield of crops from year to year. One can work out how much it costs to grow an acre of maize, for example, but whilst the manufacturer knows beforehand the precise amount of produce he will get in exchange for his outlay, the farmer's estimate is liable to great uncertainty. The only thing to be done is to obtain records of yield over a number of years. These are very lacking in South Africa, and in any case a new country is at a disadvantage in this respect; it is all the more desirable to begin recording at once. The agricultural census instituted by the Union Government is an important step.

The other difficulties in the way of cost-accounting are such as are familiar in the case of manufacturing, too. They may be grouped under three heads:—

(*a*) *Separation of Capital and Current Outlay.*—In the case of what is obviously capital expenditure, interest must be

allowed at a reasonable assumed rate—about that at which capital for farming may be borrowed on good security, and a depreciation allowance made, based on the estimated life of the goods considered. That is, an allowance such as, accumulating at the assumed rate of interest, will pay for renewal of the capital goods at the end of their life. In the case of outlay which lasts a few years the principle is the same, but it may resolve itself in practice into an arbitrary rule. Thus, if a field be well manured, perhaps 50 per cent. of the cost may be charged against the current crop and smaller portions against the second, third and possibly fourth year's crops. A slight arbitrariness in the rule is of no consequence, provided it is a sensible one and is carried out consistently.

(*b*) *Supplementary Expenses*, such as the salary of a manager, or the use of a horse and cart, have to be distributed over the various crops (or live stock business) according to some reasonable principle. Again, it is not difficult to arrive at a working rule based on common sense. But there is some danger of supplementary costs being overlooked altogether: farmers often think the cost of production of a particular crop less than it is, because they overlook certain expenses which are not directly associated with it, but which nevertheless have got to be met out of some resource or other.

(*c*) Farming, even more than manufacturing, yields "joint products," such as wool and mutton, wheat and straw. Much care is needed in dividing up outlay that is incurred in producing the two things together. For a discussion of this matter I must refer to more lengthy articles or books.

When all the money outlay has been correctly allocated, there are still two important points to be dealt with in estimating profits (or loss). First, the farmer's own capital must be treated precisely as if it were borrowed—that is, it is just as much entitled to interest. One cannot say that farming yields a profit until it has at least paid what the farmer could have earned by lending out his capital instead of using it himself. Second, the farmer's own time must be treated with similar consideration. If he does the managerial work himself, he is entitled to an income for it corresponding with what he would have to pay another man to manage his farm.

Accordingly the proper estimate of profits is only that amount which is left after working expenses in the ordinary sense, interest on the farmer's capital, and payment for his own time and skill have been deducted from the proceeds.

These principles may be illustrated by some figures which the author has collected. They are sketchy and imperfect, for it was not practicable to complete the investigation; they are, moreover, out of date, on account of the extraordinary rise in prices since the date they refer to. Consequently the intrinsic interest of the figures given is slight: they are put forward chiefly as examples of method, and to draw attention to the importance of further and systematic studies.

The figures refer to maize growing, and incidentally to the cost of ox labour. The latter point may conveniently be taken first.

Oxen can be used for some years, and then fattened up for the market and sold, often at a higher price than they cost in the first place. This is apt to make the farmer think that ox labour costs nothing, or next to nothing. A more detailed examination does not confirm the view, however. There are, of course, profits to be made from breeding stock, but to answer the immediate question we must consider trek oxen apart from other cattle.

It is true that depreciation is trifling. If, for example, a four-year-old animal costs £12, and can be used for, say, five years, then fattened up and sold at £15, we need to know the losses to allow for meanwhile. A good farmer of my acquaintance puts the loss at one animal in eight; if, however, one allows for the inferior conditions prevailing on many farms, and the possibility—even though remote—of cattle plagues, the loss is probably higher. If it be one in five, the value of the four remaining cattle just equals that of the five when bought, and the depreciation is nil.

An ox will require for pasture perhaps two morgen of good ground, worth £8 per morgen, to four morgen of poor land, worth £4 per morgen, or £16 worth of ground in either case, and even then will probably cost something for winter feed besides. There is also capital expenditure for dip, water supply and fencing, which we will put at £160 for a herd of forty. Thus we have:—

Capital Cost:	Ox ...	... £12		
	Land	... 16		
	Dip, etc. ...	4		
		32	at 7 per cent. interest =	£2.24
Depreciation on Dip, etc., say, 5 per cent. on £4 ...			=	0.20

Further, the annual expenses:—

One Herd Boy (£30 a year) for 40 Cattle	=	0.75
Winter Feed, grown or purchased, say	=	0.25
Dipping and other Expenses	=	0.05
		£3.49

or £3 10s. per ox per year.

It requires pretty good management to get 140 days' actual work per beast, especially remembering the proportion of older ones that have to be fattened up for the market. Taking that figure, the cost comes to about sixpence per working day.

The foregoing figures are not taken precisely from any one farm, but are rather of the nature of guesses based upon experience; in the second example—on maize growing—the figures are the actual averages for four farms in the Orange Free State and Transvaal for the season 1916-17.

MAIZE-GROWING. (Total for Four Farms.)

Current Expenses:

Seed (partly purchased, but including also the value of maize grown on the farm and reserved for seed) ...	£255
Fertiliser	789
Native Labour (including rations, medical attendance, etc.)	1,910
Animals (cost of fodder, dipping, etc., but excluding capital costs—see below)	232
Contract Work	117
Bags	835
Miscellaneous Expenses	159
Management	1,093
	£5,390

(Two of the farms are managed by the owners, two by paid managers. In the latter case the actual salary and commission is taken. On one farm practically nothing but maize is grown; on the other the manager's time is about equally divided between maize-growing and stock-breeding, so half the salary is debited to maize. On the other two farms an amount corresponding, as closely as possible, in accordance with the amount of work done has been taken. If anything, the figure stated is an under-estimate, as it would be an exceptionally good manager who would keep either of the owner-farms up to its present standard of cultivation.)

Capital Expenses:

	Interest @ 7%	Depreciation.	Repairs.	
	£	£	£	
Value of Live Stock:				
342 Oxen = £3,600	252	*Nil*	—	
13 Horses and Mules = £340 ...	24	20	—	
Value of Buildings, Fencing, Implements, etc. = £7,600	532	497	262	
Land under Maize—884 morgen; do. Pasture for Working Cattle—1,000 morgen ... } £11,000	770	*Nil*	—	
	£1,578	£517	£262	= £2,357
			Total ...	£7,747

(The yield was 17,119 bags, giving a total cost of 9s. per bag. The excess of the selling price above this is profit in the strict sense. The average selling price was about 12s. 6d.)

It should be remarked, however, that this estimate of costs is derived from some of the most skilfully managed farms in the country, so that it is improbable that the cost of production is so low on most farms. If these farms had been in the hands of the most penurious owners, the saving in managerial expenses could hardly have amounted to £700, or one-eleventh of the total cost. This advantage would have been lost if the yield, instead of being 19½ bags per morgen, had fallen to 17½ bags. It is hardly necessary to say that inferior management would certainly have resulted in a lower yield than this, so that good and well-paid management is clearly economical.

CALIBRATION OF GERBER MILK BUTYROMETERS.

By C. O. Williams, B.Sc., A.R.C.S.,
Lecturer in Chemistry, School of Agriculture, Cedara, Natal.

Read July 17, 1920.

(*Abstract.*)

The object of the investigation was to ascertain if the centrifugal method of calibrating butyrometers, given by Day and Grimes in vol. xlviii of the "Analyst," is sufficiently accurate when making use of ordinary commercial paraffin oil and centrifuging the butyrometers to the same degree as is done when testing milk samples.

The butyrometers taken for this investigation were first calibrated by the standard gravimetric method, using mercury, and the error per unit graduation ascertained in each case. The calibration was repeated by the centrifugal or paraffin method, and the unit error in each case obtained, as in the previous method.

It was noticed that the difference between the unit errors obtained by these two methods was approximately a constant amount (0·017 per cent.) for each butyrometer calibrated. This constant difference is apparently due to the incomplete separation of the water and paraffin columns during the process of centrifuging. Therefore, when adopting the centrifugal method of calibration, it is necessary to multiply this constant by the observed volume of the paraffin column and subtract this product from the observed total error.

On testing a further lot of butyrometers by both methods and applying the correction in the case of the paraffin method, results were obtained that were very concordant with those obtained by the standard mercury method.

Lastly, it is pointed out that the correction obtained in this investigation would probably only apply when using the same brand of paraffin and centrifuging to the same degree, so that each investigator should work out a similar method and calculate the correction for himself.

NOTE ON ROCK-GRAVINGS AT METSANG, BECHUANALAND PROTECTORATE.

By A. J. C. Molyneux, F.G.S.

Read July 15, 1920.

In the report of the South African Museum for 1918 and 1919 the Director, Dr. Peringuey, refers to the existence of some gravings on rocks in the South-West Protectorate, not representing as usual animals or figures, but hoofs of animals and human feet: gravings of a new type. Casts had been obtained for the Museum, of which photographs are given in the report. Dr. Peringuey repeats a statement by the late Theophilus Hahn "that in the Namib the Bush People had signs (?) painted (?) or graved (?) to denote places where they had found water."

I have a note of seeing, in August, 1913, somewhat similar gravings at Metsang, in the Bechuanaland Protectorate, some three miles west of Pilane Siding (mile-post 984½), eight miles south of Mochudi station. At this siding an escarpment of Waterberg sandstone, facing the south, crosses the railway and merges into higher land to the west. At Metsang is a clean, level rock floor of grit, some 50 yards in diameter, in the centre of which is a hole or enlarged joint six feet across and about the same measurement in depth, but would probably be deeper were it cleaned out. It was dry at the time of my visit, but that it had been greatly frequented was shown by the polished condition of the rocky rim, brought about by the passing of feet. All around the bare floor the country is of loose red sand, so that accumulations of water, even in the wet season, are uncommon.

On the flat surface are chipped or graved the outlines of human feet of sizes ranging from those of children to that of a large adult, which measured 14 inches long. There are also the drawings of pads of canines, lions and smaller felines, to the number of about thirty. Some are faint and others sharply cut—suggesting that the gravings were done at different times. There are none of antelopes or other animals. In the originals there is no attempt to show relief—and in this they are different from those shown by Dr. Peringuey. Native legend is that the gravings were done by "ancient people."

Note.—Since writing this note I have been reminded of a paper appearing in the "Proceedings of the Rhodesia Scientific Association," 1907, vol. vii, pp. 59-61, entitled "Ruins at Bumbusi" (Wankie District), in which illustrations of rock gravings of antelopes' hoofs are given.

SOME FEATURES OF THE RELIGION OF THE BA-VENDA.

By Rev. H. A. Junod.

Read July 17, 1920.

I had the opportunity of spending a few weeks amongst the Ba-Venda during the last summer. For a long time I had wished to visit the Zoutpansberg mountains. I had heard of marvellous ferns growing in splendid gorges, and I wanted to pluck them and dry them for my herbarium. Full of expectation, dreaming of botanical specimens new to science, I reached the Gooldville Mission Station at the end of January, with a lot of sheets of desiccating paper. But the rain fell; it fell and fell again. The rivers were soon filled, and filled to such a height that it was impossible to travel, impossible to reach those picturesque hills which stood calmly in the background of the country in a provoking attitude, most of the time hiding themselves in impenetrable clouds. I had to renounce definitely the graceful ferns and the gorgeous lilies, and, confined in the comfortable hut provided by charming hosts, I turned my mind to another field of study, and called Shifaladzi.

Shifaladzi is a Venda of the Balaudzi clan, a clan which has its abode at the foot of the Lomondo Hill, a kind of big volcanic cone, standing like a sentinel in front of the big chain. He had become a Christian lately and has been baptized. He has settled on the Presbyterian Mission Station at Gooldville, and he was just the kind of man you want to get sure and full information on the customs of the tribe: a grown-up man, who has been a heathen up to the adult age, but who is now sufficiently delivered from superstition to explain the mysteries of his former life to a sympathetic inquirer. An important point for me was that he knew the Thonga language enough to understand my questions and to answer them in a way comprehensible to me. Thus, instead of collecting ferns, I gathered ethnographic data with the same zeal which I intended to apply to botany; and I may say, after all, the result was much more satisfactory, as I always thought documents on the primitive customs of humanity greatly exceed in value specimens of natural history!

The Ba-Venda are a very peculiar tribe, still little known to ethnographical science. The Berlin missionaries, who have been settled amongst them for nearly fifty years, have studied it and know it well, but they have not yet published a full account of its customs. One of them, the Rev. Beuster, had gathered a great many notes on the subject, but he died before having put them in order. His colleague, the Rev.

Gotschlink, made a summary of them and published it in our Journal in 1905. This paper covers the whole ground of the ethnography of the tribe, but, though it seems generally correct, it has only twenty pages, and twenty pages are decidedly insufficient to describe the life of an African tribe. Later on, another Berlin missionary, Mr. R. Wessmann, published a little book under the title: "The Ba-Wenda" (W in German is equivalent to V in English). But it is of a more popular nature, and does not pretend to be a scientific study. The Native Commissioner for Spelonken, Mr. Stubbs, published a short historical sketch of the Ba-Venda, in Grahamstown in 1912, and this pamphlet gives interesting data on the migrations of the Venda tribe. From four old fellows whom he questioned he gathered that the Ba-Venda came from a place called Dzata, in Central Africa, somewhere in the region of the Great Lakes, in a comparatively recent time, about two centuries ago. This Central African origin is quite probable, as we shall see later on. But about the date of the migration I take the liberty of expressing strong doubts. First, because natives seldom remember anything positive about their history or events which took place more than 100 years ago; at any rate, even if they have preserved the knowledge of facts, they are totally at a loss regarding chronology. Secondly, because I heard Shivase people many times declare that they have "their mountain" in the Bakalanga country, viz., in Southern Rhodesia. All these Venda clans (and the Malemba also) speak of their mountain. It is the place where their ancestors have been buried, and which they consider more or less as the cradle and the stronghold of the clan. I have even been told that the chief of the Shivase branch is still sending messengers to that hill to offer sacrifices to his ancestor gods. This would mean that the Ba-Venda (at least those of the royal family), even if their first origin is in Central Africa, have remained a considerable time in the Bakalanga region. This accounts for the great resemblance they bear with that tribe and for the identification they have made of the Venda god, Raluvimbi, with the Kalanga god, Nwali.

Two subjects especially attracted my attention during the long hours I passed with Shifaladzi: The kinship system of the tribe and its religious beliefs. I must not now speak of the curions features of family relations which I met amongst the Ba-Venda, and which will be explained elsewhere, but be satisfied with their religion. I do not even pretend here to give a full description of those religious customs, after having stayed only a few weeks in Vendaland. The man who would be able to do is the Rev. Th. Schwellnus, who was born in the country, and has an intimate knowledge of the language of the people. Yet I think that this paper will be useful to students of comparative religion, as I had the opportunity of obtaining a good deal of new information from Shifaladzi, and it was duly corroborated by questioning a number of other witnesses.

The Ba-Venda, as all the South African, we may perhaps say as all the African tribes, possess a double set of religious intuitions: First, the ancestor worship beliefs, the Manism, as it is now called, which constitutes the more apparent part of their religion; and, secondly, a vague monotheistic notion which is met with all over Africa. Let us begin by the monotheistic notion, and allow me to introduce to you the Venda god, Raluvimbi.

I.—Raluvimbi.

Raluvimbi is the maker and former of everything. I do not say creator, as the idea of creation *ex nihilo* is not conveyed by the native term, nor does it clearly exist in the Bantu mind. The expression everywhere used is the one employed to describe a potter moulding clay to make utensils. Natives do not bother much about creation. What is of greater importance for them is the regular falling of the rain, and Raluvimbi is directly connected with it. If rain is scarce and starvation threatens, they say: "Raluvimbi wants to destroy us!" If, on the contrary, floods spoil their fields, they say the same thing. He is therefore prayed to and sacrifices are offered to him in order to obtain rain. However, I did not succeed in getting particulars about such offerings.

Thus it is plain that a certain idea of Providence is applied also to Raluvimbi. He takes care of the tribe. He even takes care of its individual members, and this accounts for another interesting expression, which the Ba-Venda like to employ when they have escaped from danger. For instance, when a man has nearly been drowned in crossing a river, but has managed to reach the opposite side, he exclaims: "I have been saved by Raluvimbi, Mudzimu." Or, "I have been saved by Mudzimu and Raluvimbi." "Mudzimu" means the ancestor god, the regular god, the one to whom one prays and offers sacrifices. But here the meaning of the word is extended, and it is applied to Raluvimbi. This identification between two beliefs, which generally are kept quite distinct, is curious indeed. When I questioned another Venda about it, he said to me: "Is Raluvimbi not our father? Has he not formed us all?"

Raluvimbi reveals himself at irregular intervals. People sometimes say they noticed a red diffused light in a hut or outside, and they assert that it is Raluvimbi who has appeared. Falling stars and comets are also attributed to him. But his principal manifestation is in the earthquake, as he is considered as "dwelling below." The Rev. Macdonald told me that about seven years ago he witnessed one of these visits of Raluvimbi. The Gooldville Mission Station is at the foot of a hill which stretches for a long distance in an easterly direction. One day he heard a loud clamour, which arose on the west of the hill and propagated itself to the east. Women were shouting in a way which is peculiar to them, by moving

their tongues quickly in their mouths, producing a kind of tremolo on a very high pitch. Men were yelling "E-E-E!" and all of them were clapping their hands. There had just been a slight tremor of the earth. During five minutes the extraordinary clamour filled the air, and it was most impressive! The whole tribe was greeting Raluvimbi, who was passing through the country. People say that during the earthquake they also notice a noise in the sky similar to thunder. And whilst they clap their hands, to welcome the mysterious god, they pray. They tell him: "Give us rain! Give us health!" This story of a spontaneous and collective act of adoration of a Bantu tribe towards its god is most curious, and I wonder if such a demonstration has ever taken place amongst Thonga or Souto.

When asked what was the reason of this shouting, they said: "Nwali has come. It is Raluvimbi!"

Nwali, or Myari, is the Bakalanga god, and is well known all through the tribes of Mashonaland, Transvaal and Gazaland as the great giver of rain. He is said to dwell in a cave at a place called Mbvumela, in Mashonaland, somewhere on the Sabi River, not very far from the Portuguese border. People come from far away to pay him visits and to ask for rain. This is the story they tell. They enter a kind of tunnel, pass under an enormous stone hanging over their heads, and at the extremity of that subterranean way they reach an open place where the light of the sun is shining again. Huts are built there. It is a village where the wives of Nwali are residing. Everything there is very clean and neat. Nwali greets the visitors from above or from the rocks surrounding the village. He speaks in Zulu. He says: "Good morning, my children!" The travellers must keep looking to the ground, else their eyes would be filled with sand thrown by an invisible hand. Pots full of beer will appear suddenly before them, and they will drink. Tobacco also will be provided in the same way, as tobacco plays a great part in all the dealings with Nwali.* He is a good god, a great enemy of wizards, who are not allowed to approach him, and he gives useful advice to those who go to consult him.

These are the main stories which are told everywhere about Nwali amongst the Thonga and the Venda. What amount of truth there is in those descriptions I cannot say, having been unable so far to meet a white man who has seen

* It is tobacco given by Nwali which caused the curious heathen revival of "Murimi," which upset the whole Thonga tribe from Gazaland to Maputo during the years 1916 and 1917. Murimi is a deformation of Mlimo (Mudimo?), a name given to the emissaries of Nwali who were wandering about the country giving everybody a snuff of enchanted tobacco, which was intended to destroy the power of witchcraft and to bring about a new golden age, when disease, famine, and even death would be unknown.

the cave and inquired on the spot about the Nwali legend.* At any rate, the Ba-Venda apply to their Raluvimbi all the marvellous feats of his colleagues of Mashonaland. The original figure of Raluvimbi has certainly been transformed by this identification, which is no doubt the result of the protracted sojourn of the Venda tribe in the Bakalanga country.

Is really Raluvimbi, as the Rev. Gothschling says, "the rewarder of good and punisher of evil?" When I asked a Venda heathen of the Mpefu clan if indeed their god punished evildoers, he laughed. It seems that he had never put the idea of retributive justice to the credit of Raluvimbi. I think, in fact, that Raluvimbi, as well as Khudzane, of the Pedi and other Bantu deities, belong to an age in which the truly moral god, the god of judgment, had not yet been conceived!

II.—Ancestor Worship: The Badzimu.

If the monotheistic notion which found its expression in the Raluvimbi belief is very vague, the ancestor worship of the Ba-Venda is much more concrete, consisting, as it does, in precise rites, the meaning of which is not difficult to detect.

The gods are called "Badzimu" (*sing.* Mudzimu), evidently the same root as the Suto "Mudimo." Every human being becomes a Mudzimu at his death. However, he is not worshipped for a number of years. It is believed, as we shall see, that if he dies far away from home, he returns to the mountain of the clan to join his ancestors there. The rule is that in such a case he will be buried in the place where he died. A branch of a tree which continues to live when cut is then planted on the grave in order to remind where the corpse lies, because, after a number of years, his bones will have to be taken out of the ground and carried to the sacred "thaba" (mountain). Nowadays the custom is disappearing, because natives are afraid that the white people who rule the country may object to such practices and arrest the funeral party. Thus the residence of the Badzimu is on the hill of the clan or in the dense forest which is generally kept there. But in some cases they are believed to dwell in the deep pools of certain rivers—for instance, in the Makonde or at Pipiti, without speaking of the mysterious "Sidudwane," who are said to have only one eye, one arm, and one leg, who stay in the waters of the Umfundudzi Lake. But it is very doubtful that these Sidudwana are real Badzimu. They rather seem to belong to the category of the ogres or other phantastic beings, which are the product of folk-lore rather than of religion.

* At the meeting in Bulawayo, Rev. Nevil Jones told me that Nwali has two caves in the Matopo Hills, the first is the one in which he is supposed to reside, the other is his bathroom. This latter one is jealously hidden by the natives. These caves are no doubt different from the Mbvumela cave. It would be a good thing if our Rhodesian colleagues could gather all the data relating to the Bakalanga god and write the full legend of Nwali.

As regards the mode of life of the Badzimu, reports are conflicting. However, the general belief is that, in the land yonder, they have the same occupations as on the earth. They till the ground, they eat, they are married. A very interesting rite, met in all the parts of the tribe, illustrates the fact. When a boy dies before having been married, the handle of his pick is taken and laid down longitudinally at a place where two roads sever from each other, at the very angle where they separate. This handle is then secured by two pegs deeply planted on both sides in such a way that the part remaining outside of the earth is only three or four inches long, and these little poles are tied together by a white cotton string. This handle is the wife of the deceased. She will follow him and take care of him in the country of the dead. She will cook for him and cultivate his gardens. Should the deceased be married and his wife be still living, the same rule will be followed, but, instead of two poles, one will place two broken pots on the sides of the handle. These broken pots are the ones which were used in the fireplace of his village as supporters for those in which the food is cooked. Should the wife of the deceased have died before him, no such rite is performed. He does not want a special helper dispatched to him. Will he not find his regular wife yonder?

As in all the other tribes the Badzimu are worshipped by their descendants on two main occasions: Firstly, when a misfortune, especially disease, falls upon them, and, secondly, in connection with the sowing of certain seeds and the reaping of the first fruits. But this worship is submitted to very precise rules, which are in accordance with the constitutional laws of Bantu society. In fact, Bantu religion is mainly a social and family affair. There is very little place in it for individual feelings. Therefore a Venda does not reach his gods directly, by the mere expression of his devotion or by praying to them in his heart. He must perform a number of rites and pass through official intermediate agents if he wants his request to be taken into consideration by them.

Let us first describe the way he has to follow in the religious acts he accomplishes to obtain the help of his Badzimu in the case of disease. Before all, the bones are consulted. The Venda system of divination seems to be very similar to the one spread amongst all the Suto tribes. Four bits of carved ivory or bone are the main elements of the divinatory set of bones, two male and two female. Some astragalus and other objects may be present also. It differs greatly from the Zulu-Thonga system, where the astragalus bones play the principal part and where the four bits of carved ivory are entirely absent.

Suppose the headman of a village has died and his elder son has been regularly established as his heir at the head of the kraal. If after, say, three or four years one of his children becomes dangerously ill, he will run to the bone-thrower to know where the misfortune comes from. The bones are thrown. They may fall in such a way that the diviner will

ask him: "Where is the assagai of your father?" "I do not know," answers the man, "How is it? You have lost it? You are exceedingly guilty! Go and fetch one at once to take its place." And a blacksmith will be called in haste and will forge an assagai which will replace the lost one. Then that man, the father of the sick child, will go to the entrance of his hut, either on the right or on the left side. Half buried in the soil there a curious elongated stone is standing. It is the altar. The worshipper will put the assagai against that stone, take a little water in his mouth, emit it on the weapon with a sound similar to "Pha!" This is the "phasa," the true sacrificing act. And he will pray: "Pha! My father! This is your assagai. I have found it again. Leave the sick child that he may live. Pha! If it is you, grandfather; if it is you great-grandfather; if it is you, my paternal aunt (makhadzi), or anybody else amongst you whom I do not know, please have pity on me and give us life!"

This is the typical Venda family sacrifice, and it reveals to us the main features of their ancestor worship.

Notice the part played by the assagai. At the death of a headman his assagai is solemnly remitted to his elder son. He will take a very special care of it, and it is rare that a man should be so neglectful as the one of whom we just heard the story. This assagai belonged to the father, the grandfather, the great-grandfather, as far back as one can remember. They have used it; a part of their personality is still attached to it. No wonder that it should be the means of entering into communication with them. Amongst the Thonga, in some clans, one keeps a sacred object formed of all the nails and hair of the deceased chiefs glued together by a kind of wax in order to introduce the prayers addressed to them. (See "The Life of a South African Tribe," vol. i, p. 360.) It is the same idea, based on one of the main principles of magic: *Pars pro toto*. You possess a portion of something; through it you may act on the whole. The bow, the arrows, the axe of the forefathers are also used for the purpose, and may be placed on the altar. But the assagai is tabooed more than any other object.

Curious to say, women also have their assagai; it is called "Ludo." The blade is not fixed on the top of the stick (it is taboo!), but on the side, at the extremity, in the same way as a Kaffir pick on its handle. The Ba-Venda are more "feminist" than any other South African tribe I know. Amongst them women can possess cattle, and their last son inherits it, whilst the elder inherits from the father. And amongst them women also frequently perform religious acts. This may happen amongst Thongas, but it is rare, whilst amongst Vendas feminine sacrifices are of regular occurrence, as we shall see. When called upon to preside over such a religious ceremony—for instance, when the bones have revealed that the disease has been caused by a god of the mother's family, and that the offering has to be made by a feminine agent—the elder woman takes her ludo, which she has

inherited from her mother just the same as the elder brother has inherited the assagai of the father, and she approaches the irritated feminine ancestor through the same rites.

The use of the assagai of the forefathers in religious ceremonies illustrates and corroborates the fundamental law of Bantu society, viz., the law of precedence or hierarchy. The elder son is the chief of his younger brothers. He is invested with full authority over them. Bantu social life would be impossible if that law were not enforced, and religion comes to the help of social life by stating that one cannot pray to the gods without passing through the ministration of the elder brother.

Suppose that two brothers have had a dispute. The younger one wants to free himself from the tutelage of his elder. He decides henceforth to make offerings to his ancestors in his own village, on his own altar. Such an act is taboo! He does not possess the assagai of the ancestors; he is not entitled to approach them. The bones, when consulted, will tell him: "What? You have two altars, two stones in your family? It is bad! Put that matter in order!" And the younger brother will have to throw the stone of the altar away, take water in his mouth, emit it with that sound "Pha," and tell his ancestors: "I have abandoned my stone. Abandon me also. Do not come any more to do me harm! Go to my elder brother; he is the one who keeps your weapons. He will treat you well!" This intervention of the bones will probably result in the reconciliation of the two brothers. Should they even not meet at once, they will have to do it at next harvest, at the feast of the first fruits, as we shall see.

There is only one case in which a younger brother may be allowed to establish an altar in his village: it is when he is dwelling far away from his elder brother, and he cannot be expected to go a long way to obtain his religious assistance each time he wants it. But after the sacramental "Pha," after having expressed his prayer, he will add these words: "Go to those who held the assagai, they will give you what you want!"

I have repeatedly mentioned the stone of the altar. What is it? We meet here with a strange custom which I never heard of amongst South African Bantu, except amongst the Malemba, who are nearly related to the Vendas. That stone is called an ox, as, indeed, it takes the place of an ox. When a headman possesses cattle, he chooses one of his best oxen and calls it "Makhulu" (grandfather). This ox will represent the gods in the midst of the village. It is no longer an ox; it is a human being. That does not mean that the headman for ever renounces the pleasure of eating its meat. Venda devotion does not go so far! It can be killed and eaten, but, in that case, another will be consecrated to take its place. When offering libations of beer, the headman will pour the liquid on its back. Before eating the first sugar cane, he will go at sunset to the sacred ox and offer it the inflorescence which

is at the top of the cane, and say: "Eat the flower with joy, grandfather, and leave us the stem, that we also should eat it with joyful heart."

But should the oxen die, or should the headman be poor, he will consult the bones, which will say: "Never mind, if you have no ox, go and fetch a stone in the river; it will be your ox." The man will choose a well-polished, cylindrical stone, and put it somewhere near his hut. The regular place is at the entrance. The stone is half buried in the red soil, and the place all round is well smeared. Some bulbs of an Amaryllida, called "Lohome" or "Muthangwana" (belonging, I think, to the genus Hypoxis) are planted also on the spot. Shifaladzi could not tell me why. Is it in order to introduce some poetry in the religion? I do not know.

Consultation of bones, possession of the assagai of the ancestors, consecration of an ox which is a human being, or of a stone which is an ox, that ox which is a human being—one can see that there are many conditions to fulfil to reach the gods, even for the headman of a family. And for his younger brothers there is still the necessity of passing through their elder to obtain a hearing from the all-powerful ancestors.

On the other hand, Bantu, and especially Ba-Venda, do not make the worship particularly difficult as regards the nature and the value of offerings. Water is generally all that is required. Yet there are occasions on which it is not sufficient. Let us return to the case of the sick child. If the offering of water thrown from the mouth on the altar has not been successful in curing him, the bones consulted for a second time may say: "The angry god is not satisfied. He asks for a goat to clothe him" (mbudzi ya u dzwindisa). This will be a real sacrifice, and it will be performed in this very curious and significant manner.

A goat will be provided. It is put before a basin of water mixed with certain drugs and forced to drink, to drink till it is full of it, till it dies. It is then skinned and cut open. The large intestine is extracted from the body, a part of it is cut and stitched at one of its extremities so as to form a kind of pouch. From each limb a bit of meat is taken, and quite a provision of seeds of "mufoho" corn, millet, mealies brought on the spot, together with drugs. All these kinds of food are introduced into the pouch, this filling up being accompanied with prayers to the ancestor spirit. And whilst the father proceeds with it, he puts seeds in the goat's intestine with one hand, and, with the other, he takes other seeds and places them apart. These he will keep carefully, to sow them later on. And he goes on praying: "Eat plenty and be satiated," does he tell the ancestor, "and leave us some for our use." This part of the goat's intestine has become a person. It is henceforth identified with the deceased grandfather. Thus the god has been fed, duly stuffed. The pouch is then stitched at the other extremity. But now the ancestor must be clothed also! A strap is cut out of the goat's skin, and the sacrificer winds it all round the pouch. Carrying the

offering with him he now goes to the grave of the grandfather, digs a little and lies the pouch in the earth parallel to the body which is beneath, and he prays again: "We worship you, grandfather! And we have clothed you. This is your food. Eat and be full and be contented. And leave us food, plenty of food, that we also may be contented, and bless the sick child."

This is the rite of the "goat with clothes." Really a perfect illustration of Bantu ancestor worship, where sympathetic magic plays an important part.

The second category of offerings, as we said, are those connected with the agricultural life of the tribe.

If the rites performed in the case of disease reveal the sense of dependence in the Bantu soul, but also the fear towards its ancestor gods, it is in the agricultural rites we meet with some higher features of the religious feeling—an aspiration to the communion with the dead forefathers and an expression of thankfulness towards them.

These agricultural rites are performed on two main occasions, at the sowing and at the reaping of the "mufoho" corn. This "mufoho" (*Eleusine indica*), a cereal one or one and a half feet high, bearing three or four spikes at its extremity, somewhat like a Panicum, is the staple food of the Ba-Venda, and no doubt the oldest of their cereals. For the modern ones, sorghum, mealies, which have been introduced later on, no rule is observed. Mufoho* corn only is tabooed.

And the taboo is very strong indeed. Formerly a Venda who dared to reap his mufoho before the religious ceremony had taken place was put to death.

These two rites are not only family, but national rites. They are national in this sense, that they are accomplished with a special lustre at the chief's kraal; but they are also family in this sense, that they are repeated at each headman's kraal.

The sowing rite is associated with the curious custom called "Uzonda." When a headman has grown-up children, they all must come at the time of tilling and help him to cultivate a small garden which belongs to the gods. Should this man die, the elder son inherits that field, and his brothers and sisters must continue to assemble and till it and sow there the first seeds of mufoho before they start cultivating their own gardens. It is a taboo. Should they not observe that rule, they would obtain nothing in their fields—another instance in which religion intervenes to uphold the fundamental law of precedence. Younger relatives, if staying far away from the head of the family, must at least send some seeds for the sacred field.

At the capital this uzonda assumes greater proportions. The chief summons his neighbours and relatives to till this special field. Little girls are committed to the task of cooking a dish of native peas, and women prepare beer of

* Mufoho is called "Mphoho" in Thonga.

mufoho corn. When these girls go over the country to gather wood and fetch water for their cooking, they handle small sticks, and are ordered to thrash everybody they meet on the road. And the people, when they see the girls approaching, must kneel down at once and cover their faces with their hands. This is meant to be an act of adoration and of self-humiliation towards the powerful gods of the royal family. By this prostration subjects declare that they are "dead," they have no power at all. The power belongs to the gods, the gods of the chief; they alone can make the corn grow!

When the tilling is finished, workers take part in the meal of native peas, and the mother of the chief takes her ludo and prays to her deceased mother, grandmother, paternal aunt—all the royal feminine gods. She says: "We give you beer to drink. Give us corn, that it may grow, be plentiful, and that we may eat." It seems that this ceremony is entirely in the hands of women, and no wonder in the fact: It is closely connected with the agricultural life, and women play the greater part in it.

The same religious act is performed in all the headmen's zonda fields, but, amongst subjects, there are no girls armed with sticks and beating the poor people.

The second agricultural rite takes place at the time of reaping, and corresponds to the feast of first fruit, which is one of the oldest and most widespread features of Bantu religion. It is called "tungula mufoho," the consecration, or offering of mufoho corn, and must be performed at the capital and at headmen's kraals before the people are allowed to reap. In the headmen's kraals beer is made from the new harvest and poured on the back of the ox-grandfather, or on the stone of the altar. Should the headman be at the same time the head of a clan which possesses its mountain, the offering is carried to the sacred wood where the ancestors are supposed to reside.

But, as regards the Shivase royal family, the beer is solemnly conveyed by two messengers to the place called Gubukubu, on the Pipiti River, where one at least of the Shivase ancestors has been buried. There is a pool there, and the whole place is called "Badzimon" ("at the gods"), a rock which penetrates into the river and is seen emerging from it. The two priests walk over it up to its extremity, and there they pour the offering of beer and pray for the country, for its peace and prosperity. It is said that after their departure the gods come out from the water and drink the beer.

It is interesting to note who are these two sacrificers. The one is the chief or his representative; he has the power to address the ancestors of the royal family, as he is their elder son, the regular heir. The second one belongs to the clan of the Ba-Ngona. These Ba-Ngona were the first owners of the country. They were subdued by the Ba-Venda at the time

of their invasion. In that way man can approach the gods who were the original possessors of the land and obtain their blessing, which is always a good plan, as it would be unwise to provoke the anger of any of the departed spirits. On the other hand, the father of this second priest, who is a Ngona, has married a woman from the Shivase family. In this way this man is a "moduhulu," namely, a uterine nephew of the Venda chiefs. The uterine nephew everywhere plays a special part in Bantu ancestor worship. He is the favourite of his malume, viz., of his mother's brother. Heir of the Ngona gods, nephew of the Ba-Venda, he is really the right man in the right place when he assists the chief in this important function.

III.—Totemism.

One may find it strange that totemism should be mentioned here in connection with religion. Totemism is prevalent amongst all the tribes of the Suto group, Basuto of Basutoland, Ba-Pedi of Transvaal, Bechuana, etc. But it consists merely in a few more or less obsolete rites and in taboos concerning the killing of the totem animal and the eating of its meat. I do not know of any relation established between the totem and the ancestor gods amongst those tribes.

Amongst Ba-Venda, at least amongst some of their clans, this relation exists most decidedly, and it is one of the most interesting discoveries I made when studying their religion. This applies mostly to the Ba-Laudzi, Ba-Nngwe, and Ba-Shidzive clans, all of which have their "mountain" in Vendaland.

Let us begin with the Ba-Laudzi, the clan to which belonged my principal informant. Their totem is the baboon. They are called "Ba-ila-pfene," those who taboo the baboon. (Strange to say, I never heard the expression always employed in Suto tribes: ba-bina-pfene, those who dance to the baboon.) Baboons are considered as bearing a special relation to the clan. When they enter the gardens and steal mealies, one may chase them, but it is taboo to pick up any cob they may have let fall when running away. Sometimes they penetrate into the village; they enter the special hut where women stamp their mufoho corn. This hut is found in every Venda village; it has no door; the floor is made of very hard clay, in which are buried four or more little mortars up to the level of the ground; women grind the cereal on their knees with short pestles. The baboon visitors are allowed to take a little of the grain; however, if they steal too much and become troublesome, they are chased away. Naturally the Ba-Laudzi do not eat their meat. There is nothing very peculiar in these customs; similar dealings with the totem animal are found in all the totemistic South African tribes. But here comes the proper Venda theory: It is believed that these baboons are the Badzimu themselves. Each Mu-Laudzi, when he

dies, becomes a baboon and goes to the sacred hill of Lomondo to dwell there. There is a specially big baboon amongst them. It never utters a cry. It is very old. It is the chief of the flock, and the principal ancestor god. Only when a great misfortune threatens the tribe one will hear it coming out of the forest and shouting loudly. Should a member of the clan die far away from the Lomondo, it is the old baboon which will go, accompanied by others, to fetch the new Mudzimu, who has been transformed into a baboon, and it will bring the new god to the sacred hill. At the time of the first fruit ceremony, the consecrated beer will not only be poured on the back of the ox-grandfather, but part of it will be brought to the forest of the gods and poured on a rock for the baboon god. And when the party which went into the forest returns to the village, one will hear a loud cry. It is the old baboon, who once more has abandoned its obstinate mutism to express its thankfulness for the offering. Then all the women assembled in the villages at the foot of the hill will burst into cries of joy, those same peculiar yells with which they greeted Raluvimbi when he visited the country.

Similar customs are prevalent amongst the Ba-Nngwe, the clan of the leopard, who have their mountain in the north of the country. It is strongly forbidden to them to kill a leopard: it will mean killing the ancestor god, and the man guilty of such an offence would die.

The Ba-Shidzive have the lion as totem. Their mountain is situated in the place called Thathe, and is the residence of Nethathe, the big lion, who is also their great ancestor god. It is believed that, though all the members of the clan become lions at their death, most of them spread all over the country where it is not prohibited to kill them. The only one which is taboo is the lion chief in the forest. However, men of this clan do not eat lion's meat at all.

If I were treating the subject of totemism fully, there would be much to say about the Ba-ila-singo, viz., those who taboo the elephant's trump, who are the members of the royal family; the Ba-ila-Ndowu, who venerate the elephant itself, and have many sub-divisions; the Ba-Ngoba taboo the mushroom; the Ba-Keebo, the wild boar and the pig; some clans have birds as totems. Venda totemism, I venture to say, is a wide subject of inquiry, which I am far from having fully studied. I wanted only to explain the striking relation established in some clans between the totem animal and the ancestor god, and on the belief in a kind of transmigration of souls, which is by no means common amongst Bantu of these parts.

Will it be possible here to find the explanation of totemism, this complex of ideas and superstitions so curious, so vague, so incoherent? It has often been thought that the veneration showed to the totem animal came from the assumption that he was the originator of the tribe which has adopted it. Would it not be more probable that, on the contrary, the

totem animal is feared and venerated, eventually worshipped, because every member of the clan is transformed into it, and because in this way the ancestor gods have come to be identified with it? If such were the origin of totemism and its relation to ancestor worship, then the belief in the transmigration of the souls of the deceased into the totem animal ought to be considered as a primitive conception; it could be admitted that the more southern tribes have lost this connection and preserved a disfigured totemism without relation with their religion, whilst all the Zulu-Thonga group has altogether abandoned the totemistic idea.

I have found an indication showing that the evolution has probably followed this course. Whilst I was thinking that the identification of the ancestor god and the totem was something quite new, I happened to read a book of a German traveller, the Duke Adolf Fred, of Mecklenburg, entitled "The Heart of Africa," where, speaking about the tribes living in Central Africa, he says: "Each clan reveres a totem, which in Kindjoro is called 'Umzimu.' Should the totem take the form of an animal, it is forbidden to kill or eat such animals. This interdiction . . . is closely connected with the belief of transmigration of souls; for their creed teaches that spirits of their departed relatives enter the body of the object of their adoration. In Ruanda the souls of the deceased rulers are believed to dwell in the leopard, and to continue to torment their people in that shape."*

I need not emphasise the importance of this remarkable correspondence between the Venda and the Central African belief. The belief itself throws a very welcome light on the whole subject of totemism, and the correspondence greatly strengthens the hypothesis that the Venda tribe has come from the heart of Africa, where the totem and the ancestor god are so fully identified.

No doubt a more complete study of the Ba-Venda will yield some more surprises.

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* May I add that, since writing this paper, I have seen "The History of Melanesian Society," by W. H. Rivers, vol. ii, and that he describes a condition of things amongst Melanesian people very similar to the one I have just explained amongst the Ba-Venda. According to that distinguished anthropologist, Melanesian totemism owes its origin to the fact that the Kava people brought with them their belief in the incarnation of their ancestors in animal form. This, he thinks, was the starting point of Melanesian totemism. It is surprising to see that in the kingship system also there are striking resemblances between the tribes of Melanesia and Polynesia and our South African tribes.

THE OCCURRENCE OF "TERBLANZ" (*FAUREA MACNAUGHTONII*, PHILL.) IN NATAL AND PONDOLAND.

By E. P. Phillips, M.A., D.Sc., F.L.S., and
J. J. Kotze, B.A., D.Sc.

Read July 15, 1920.

Since publishing our note on the genus *Faurea* (S.A. Journ. Science, vol. xvi, p. 232) we have seen further material of *Faurea*. The examination of this fresh material has confirmed what we suspected, namely, that *F. Macnaughtonii* and *F. natalensis* are specific.

Faurea natalensis, Phillips, was described ("Flora Capensis," v, p. 641) from a single specimen collected by Gerrard in Natal, and was separated from *F. Macnaughtonii* on the smaller flower buds. Forester Tustin submitted a specimen recently collected (Forest Herbarium 2961) at the Ngomi Forest, Ngotshe Division, Natal, which has buds up to 9 lines long and styles up to 10 lines long and agrees in every other respect with specimens of *F. Macnaughtonii* from Knysna. In comparing this specimen with a large series of specimens from the same tree (Forest Herbarium 2331) collected in the Ntsubani Forest, we find every gradation in the size of the buds from 6 up to 9 lines long, and the same gradation in size occurs in the Knysna specimens.

In view of these further facts, we now regard the species hitherto known as *F. natalensis*, Phill., and *F. Macnaughtonii*, Phill., as one and the same.

As the Knysna tree is the better known and the name *F. Macnaughtonii* generally accepted by foresters, we propose that this name should stand:

F. Macnaughtonii, Phillips, "Flora Capensis," v, 1, p. 642 (*Kotze and Phill.*, S.A. Journ. Sc., xvi, p. 236); *F. natalensis*, Phill., "Flora Capensis," v, 1, p. 641 (*Kotze and Phill.*, l.c., 235).

The Knysna "Terblanz" therefore occurs in the Knysna Forest, then appears in the Pondoland Forests, and reappears in the Ngomi Forest in Northern Natal.

A METHOD OF VELD ESTIMATION.

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(*Abstract.*)

Read July 17, 1920.

This method originated from the necessity of making a very close study of certain stock disease-bearing velds occurring mainly in Natal, Zululand and East Griqualand, the diseases being caused, in the opinion of various veterinary collaborators, by some plant, plants, or even a condition of the veld herbage.

Several diseases were investigated, of which the principal are stijfziekte, dunziekte and cattle pushing-staggers, the latter now happily solved by the application of the method.

The problem set to the botanist was to find the plant, and, having adduced enough evidence to incriminate any plant, it was then necessary to prove this to be the plant cause by applying the crucial test of feeding the plant to animals and producing in them the typical disease. This latter test, of course, was carried out by the veterinarian.

Initially, the method adopted was to list separately all the species occurring on as many intensely "diseased" areas as possible, choosing those farms most widely separated, in order to secure geological and climatic differences as well.

The plant-lists were arranged both ecologically and systematically for each farm. These local lists were then compared for all areas carrying the same disease. At once the eliminative effect of such a process can be seen to give one relatively small common-factor lists, the size of which being of practical dimensions, enabled one to test each plant separately. However, a further use was made of these lists. As the lists recorded the range of variation of a species in form, habitat and distribution on intensely "diseased" areas, it was sought to ascertain whether there was in these data any correlation to the disease, *i.e.*, any ratio or other factor, such as the relation of genera to species, common genera to the common species, etc.

To test this, it was easy to count the species, genera and orders for each locality, reducing all ratios to percentages and comparing them in pairs. Some interesting results were obtained, and I give the final extract figures for four widely separated dunziekte areas in illustration.

(a) *Total Genera* : *Total Species*:—Mooi River and Kokstad, 44·4 : 55·6; Rosetta and Kokstad, 41·7 : 58·3; Molteno

and Kokstad, 31·6 : 68·4; Molteno and Mooi River, 33·3 : 66·6; Molteno and Rosetta, 32·2 : 67·8; Rosetta and Mooi River, 36·1 : 63·9; any three areas, 26·4 : 73·6; four areas, 35·1 : 64·9; average, 35·1 : 64·9.

(b) *Common Genera : Common Species*:—Mooi River and Kokstad, 44·1 : 55·9· Rosetta and Kokstad, 44·3 : 55·7; Molteno and Kokstad, 44·3 : 55·7; Mooi River and Molteno, 43·9 : 56·1; Rosetta and Molteno, 44·4 : 55·6; Rosetta and Mooi River, 44·9 : 55·1; any three areas, 44·5 : 55·5; four areas, 44·4 : 55·6; average, 44·3 : 55·7.

The figures for "Total Genera : Common Genera" and "Total Species : Common Species" have been omitted, as the results are of the same order as those given above (a), and were not unanticipated, the ratios expressing the variations due to purely local conditions.

The figures for Common Genera : Common Species are remarkable, giving practically a constant, and seem to suggest some biological relation. To test this, I compared many non-dunziekte lists with these, and no correlation was found to obtain. I have therefore postulated that: "A farm is a potentially dunziekte area if the systematic list analysis of its flora, when compared with the floral systematic lists of several well-defined dunziekte farms, shows a ratio of common genera to common species of 44·3 : 55·7; and, further, this area may become actively dunziekte-carrying by over-stocking and burning for a few seasons." This latter statement is the result of observations and analysis of a great many dunziekte areas.

The ecological analysis further enabled one to state that dunziekte is associated with the vegetation characteristic of a definite geological formation, namely, the predominance of Karroo shales (carrying fossils of *Glossopteris* spp.) on the areas in question.

But both of these methods failed *in themselves* to supply the information required, that is, where a *condition of the veld* (proportion of species present, grazing value, botanical growth state as apart from species lists) was as much likely to be a factor in the causation of the disease as well as, or irrespective of, any specific plant in the area. This seems to be so with stijfziekte, and in some degree with most other such diseases.

In illustration, three adjacent paddocks on the same ridge at Lidgetton, Natal, are here instanced, each owned by different farmers.

Paddock A.—Forty-five acres. Almost unbur ed and but slightly grazed for thirty years. Floral composition and state nearly that of the primitive veld. Stijfziekte free.

Paddock B.—Forty-three acres. Burned and over-stocked (cattle) for thirty years. Greatly altered veld. Definitely stifjziekte carrying.

Paddock C.—Forty acres. Burned seven odd years, mown several years, stocked eight years, then fallow eight years, then over-stocked two years, veld altering, slight stifjziekte.

To estimate the differences in such paddocks, careful

systematic lists were made, revealing a difference of only three species, which occurred in minute quantities. Hence a new method had to be devised. I, therefore, sought to *count* the individuals of species present by taking representative strips or samples ("belt transects," Professor J. W. Bews has named them) in each ecologically different area in order to calculate the proportion of every species present. Then, by reducing to percentages, the lists for each paddock could be compared and graphs drawn representing the range of variation.

Typical belts, 10 feet by 150 feet (longer or shorter as necessary, and T- or L-shaped when required), were selected and laid down permanently by pegging. White twine was stretched between the pegs, and the method of counting was as follows: Each 10 feet square was estimated separately for (a) the number of individuals, and (b) their percentage, the records being entered on specially printed forms. It was soon found that the unit 1 foot square (*i.e.*, 1 per cent.) was too large; and I divided the plot into four by cross bands of twine, and the new unit, 6 inch square, was very convenient for these closely grassed areas.

The vertical shade area of the plants was taken in estimating their percentage proportion. For grasses the 6 inch square unit was again divided into five (viz., $2\frac{1}{2}$ inch square) in order to estimate exactly the extremely variable sizes of the tufts. Graphs were plotted only for the average of 10 feet square plots.

Remarkable results followed the application of this method, both in interest and importance. The results of analysis of three belt transects from each of the three paddocks aforementioned, will be given in illustration, only the principal plants being selected, the average percentages being cited:—

Anthistiria imberbis: A 63·4; B 27·63; C 53·4.
Elionurus argentus: A 5·0; B 23·56; C 7·24.
Eragrostis plana: A 0·5; B 4·57; C 4·91.
Eragrostis chalcantha: A 2·0; B 7·4; C 5·8.
Sporobolus indicus: A 0·1; B 0·63; C 0·2.
Harpechloa capensis: A 0·6; B 2·05; C 0·71.
Tristachya leucothrix: A 1·5; B 3·23; C 1·94.
Paspalum scrobiculatum: A 2·5; B 5·24; C 2·31.
Axonopus semialatus: A 2·0; B 5·18; C 2·8.
Panicum serratum: A 0·5; B 3·92; C 3·21.
Bulbostylis sp.: A 0·001; B 0·77; C 0·0013.
Vernonia natalensis: A 1·50; B 0·18; C 1·05.
Acalypha depressinerve: A 1·5; B 2·91; C 2·14.
Acalypha Wilmsii: A 0·2; B 1·21; C 0·317.
Pteridium aquilinum: A 2·0; B 3·24; C 2·24.
Pentanisia variabilis: A 1·5; B 0·002; C 0·86.
Watsonia densiflora: A 5·0; B 0·0025; C 0·135.
Vangueria: A 0·001; B 0·75; C 0·21.
Rhynchosia nervosa: A 4·5; B 3·15; C 4·3.

Examination of these figures will at once show:—

1. The enormous drop in the percentage proportion of the best grazing grass, *Anthistiria imberbis*, the "blue grass" of Natal, by the veld treatment accorded.

2. The increase in proportion of useless grasses, notably *Elionurus argenteus*, to replace *Anthistiria*. (*Elionurus* was not only avoided by the "army worm" when all else was eaten, but cattle tethered on this grass rather starved than ate it.)

By making graphs there is apparently an intimate relation between *Elionurus* (with one or two other grasses) and *Anthistiria*. A distinct correlation, as set forth in (3), seems indicated.

3. That an exact estimate of the grazing value of each paddock can be calculated. Paddock A is a typical sample of the good grazing in central Natal. Paddock B, adjoining, is now a poverty veld; B's cattle grazing this paddock never thrived on it, and contracted stijfziekte. Our experimental cattle have contracted stijfziekte in as short a time as three weeks after being removed to Paddock B, having grazed in Paddock C for over a year. The method thus gives us a quantitative estimate of details of this description. The results are valuable, as there is no reason to suppose that thirty years ago the three paddocks were not identically similar in average botanical composition.

But the method has a fairly general application in the exact detailed estimation of (1) veld change, (2) veld composition, (3) distribution of vegetation—that is, ecological values.

I will briefly indicate some of the uses:—

1. The quantitative estimation of the grazing value of any farm at a particular time for land valuation, and, by continuous observations, the effect of such factors as season, burning, stocking, drought, ploughing, etc., could be estimated.

2. The quantitative and qualitative estimation of the relation of vegetation to the soil by comparing such belt transect samples taken from different localities bearing the same soil. As such estimations can be carried out with extreme accuracy, such a method used in conjunction with soil survey and analysis would yield invaluable records.

3. Estimation of the actual, and prediction of the possible, effect of burning of any specific veld, especially if continuous burning is practised. All my graphs of burned veld show this remarkably clearly.

4. In a transect taken from ridge downwards through a marsh most striking results were obtained. These go to show that (a) plants exhibit a very definite zonation in their euhabitat. Thus, if a tacheometrical survey of such an area were made, taking vertical intervals of 1 foot on a slope of about an angle of 10 degrees, then each contour line plotted would represent almost exactly the zonation exhibited by a different species in the descent from ridge to vlei. (b) A com-

parative chart of graphs for the figures for such a transect shows one mass of points, or apices of graphs. The position of any apex in a graph fixes the *euhabitat* in the transect of the species concerned.

This result was invaluable to me, as giving me the key factor to the plant which was proved to be the cause of cattle pushing-staggers. For its euhabitat in 1917-18, and eight years previously from accounts, was found to be in a narrow belt along stream and marsh edges, half in and half out of water (namely, amphibious, not necessarily semi-submerged). In 1918-19 and 1919-20 its zonal habitat, owing to abnormal rain, was increased to belts 20 to 200 yards wide in ridge to vlei transects of low angle, 3 degrees to 6 degrees. The outbreak of this disease coincided with increase in spread and growth of this plant. It was accordingly arranged to be fed, and it produced the disease.

5. As information concerning climate, rainfall, temperature, humidity, frosting, altitude, locality, etc., are recorded concurrently with the estimation of a number of transects on an area, it can well be seen that if a number of botanists, using the same units, were engaged in such survey throughout the country, and such surveys were collated and compared, then the most valuable and exact data could be had as to—

(a) The geographic distribution of species, and the causes of such distribution.

(b) The practice of veld burning in the various floral regions of the Union, so that uniform laws could be drafted regarding its advisability, etc.

(c) The systematic valuation of the ranching and agricultural possibilities of all the land in the Union (in conjunction with the soil survey).

(d) The causes of the disappearance of valuable timber, herbage and wild flowers could be ascertained, and control of these baneful factors instituted.

NOTE ON A DIAGRAM SHOWING THE AMOUNT OF AVAILABLE SUNSHINE FALLING ON A HORIZONTAL SURFACE ON ANY DAY OF THE YEAR AT A GIVEN PLACE, AND SHOWING ALSO THE SUN'S ELEVATION AND ITS TIMES OF RISING AND SETTING.

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With Three Text Figures.

Read July 15, 1920.

1. The diagram described in this note was found serviceable to students attending a short course on meteorology given in 1919 in the University of Stellenbosch. It is probably not new, but has not been met with in any of the text-books or journals available to the writer. It can be constructed easily in schools as an exercise on sines and cosines, and may be helpful in supplementing the open-air observations, which should be a part of all school courses on geography.

2. If the intensity of the sun's radiation be regarded as constant, the amount which falls per minute on a horizontal surface at the upper limit of the atmosphere at any given place is, of course, proportional to the sine of the angular elevation of the sun above the horizon. This amount may be regarded as measuring the intensity of available sunshine at that place. The construction given below provides an easy graphical method of determining the sine of the sun's elevation at any hour of any day, and hence of calculating the available sunshine.

3. If we apply the well-known formula of spherical trigonometry

$$\cos a = \cos b \ \cos c + \sin b \ \sin c \ \cos A$$

to the spherical triangle whose apices are P, the south pole of the heavens, Z, the zenith, and S, the sun, we have (see Fig. 1)

$$\cos ZS = \cos ZP \ \cos PS + \sin ZP \ \sin PS \ \cos P$$

Here S may be taken to represent either the true sun or the "mean sun." As the latter proceeds uniformly along the ecliptic, and as its hour-angle P changes in strict keeping with an ordinary clock, it is convenient to apply the formula to the "mean sun" and draw our sunshine diagram for the latter, leaving to a later stage the small corrections for the difference between the positions of the true and "mean"

suns, and for the difference between local mean time and standard South African time. *P* is then the hour-angle of

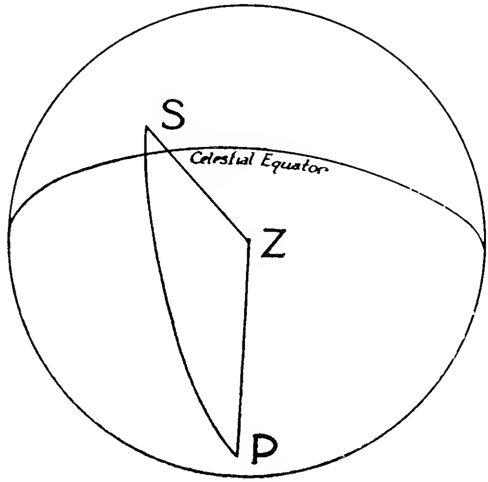


Fig. 1.

the mean sun at the spot of the earth's surface for which the diagram is to be drawn—in other words, it is true local mean time reckoned from noon.

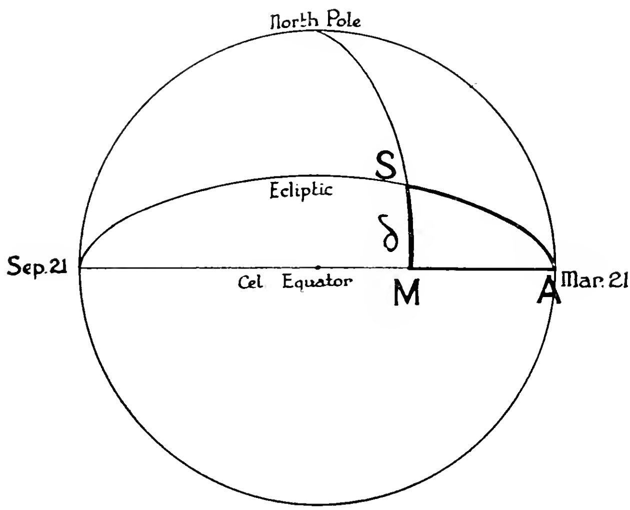
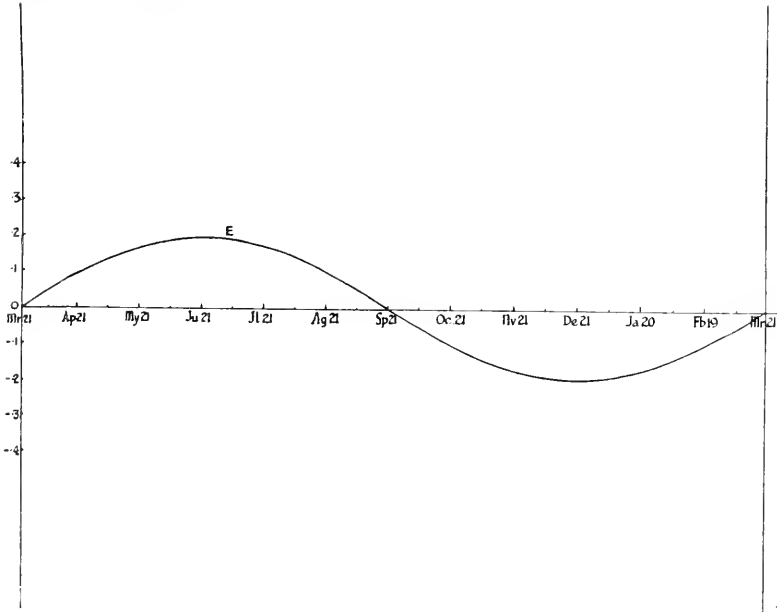
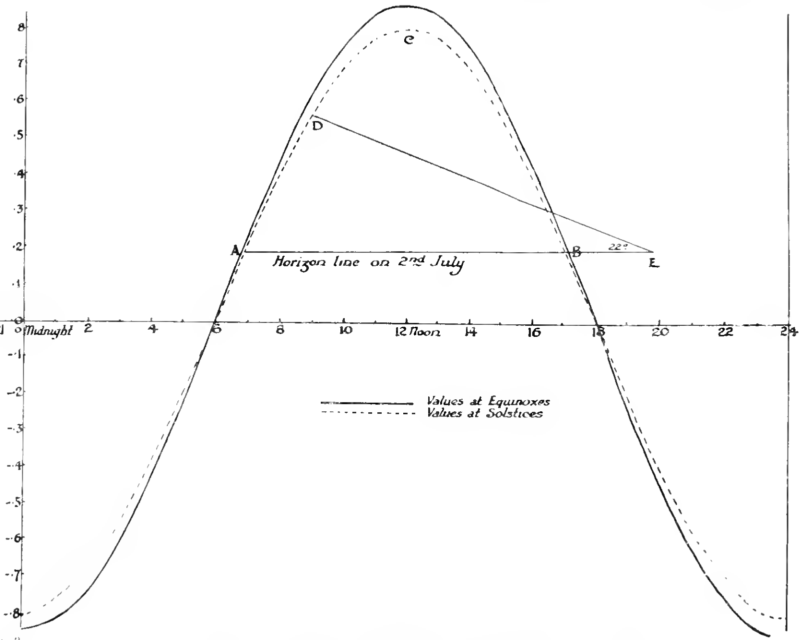


Fig. 2.



Values of $\sin\lambda \sin\delta$ for different months of the year Lat. 29° 5′ S.

Fig. 3.



Values of $\cos\lambda \cos\delta \cos P$ for different hours of the day Lat. 29° 5′ S.

To face p. 229.]

We may write

$ZS = 90° - h$, where h = altitude of the mean sun,
$ZP = 90° - \lambda$, where λ = S. latitude of the place,
$PS = 90° + \delta$, where δ = angular distance of the mean sun north of the celestial equator,

and the formula reduces to

$$\sin h = -\sin \lambda \ \sin \delta + \cos \lambda \ \cos \delta \ \cos P. \qquad (1)$$

In this formula $\sin \lambda$ and $\cos \lambda$ are constants for the given place. $\sin \delta$ varies throughout the year exactly in proportion to the sine of the angular distance of the mean sun from the equinox of the 21st of March, and therefore completes its fluctuation in a year.

In Fig. 2 we have

$$\sin SM = \sin A \ \sin AS.$$

i.e., $$\sin \delta = \sin 23° \, 27'. \sin (n \times 30°),$$

where n = number of months of equal length that have elapsed since the 21st of March. Hence

$$\sin \lambda \ \sin \delta = \sin \lambda \ \sin 23° \, 27'. \sin (n \times 30°), \qquad (2)$$

and the value of this term can be represented by a curve of sines throughout the year. In the second term on the right-hand side of equation (1), $\cos \lambda$ is, of course, constant, and $\cos \delta$ is nearly so, its value varying only from unity at the autumn and spring equinoxes to 0·917 in June and December. Hence the value of the second term during any day can be represented by a curve of cosines, the amplitude of the curve changing slightly every three months.

4. The left-hand side of the diagram, Fig. 3, gives the values of the term $\sin \lambda \ \sin \delta$ throughout the year for the latitude of Bloemfontein, while the right-hand side gives that of $\cos \lambda \ \cos \delta \ \cos P$ throughout an average day, the continuous curve corresponding to a day at the equinoxes and the broken one to the solstices. If, now, from the point on the first curve corresponding to any given day a horizontal line be drawn across the second curve, this line will represent the horizon for the day. It will cut the second curve at points corresponding to sunrise and sunset, and the hours of the rise and setting of the mean sun can be read off at once in true local time. The height of the second curve above the horizontal line is the sine of the sun's altitude, and is therefore proportional to the intensity of available sunshine, and the whole area above the horizontal line is the total available sunshine for the day, save for the correction due to the deviation of the "mean" from the true sun.

For example, in the diagram which is drawn for latitude 29° 5′ S., the point E on the first curve corresponds to 2nd July; AB is drawn through E parallel to the line of abscissae; the dotted area $ACBA$ is the total available sunshine on that day in latitude 29° 5′ S. The "mean" sun rises about $6^{h} \, 54^{m}$ a.m., local time, and sets about $5^{h} \, 6^{m}$ p.m. Further, if from the point D, corresponding to 9 a.m. local time, a line of unit length DE be drawn to cut the horizontal line,

the slope of this line gives the angular elevation of the "mean" sun—in this case 22°. The height of the sun at any other hour—say midday—is obtained in the same way. In schools all these results can be compared with the values observed by simple methods.

5. For the true sun the following corrections may be applied:—First, the values of the equation of time can be entered on a corner of the diagram or graphically, and the position of the true sun can hence be shown by dots placed on the first curve. The horizontal line for any day drawn from the corresponding "true" point will then give the sine of the elevation of the true sun, its true local times of rising and setting, the true amount of available sunshine, and so on. Secondly, to get the corresponding times on a local clock, we add or subtract the equation of time and the difference between local and standard South African time.

6. It need hardly be added that all the diagrams can be constructed completely with the help of a divided ruler, pair of compasses and divided circle, without the use of tables.

NOTE ON OLDER PALAEOLITHIC IMPLEMENTS FROM THE UMGUZA AND BEMBESI VALLEYS.

By A. W. Macgregor, B.A., F.G.S.

With Plate XXX.

Read July 15, 1920.

This note is intended mainly as a record of the localities where older palaeolithic implements have been found to be abundant, and a description of the types represented and the conditions under which they were found. The types are generally comparable with those of the European succession, but as yet no very definite evidence has been adduced to prove that they have the same chronological significance.

The occurrence of implements from the neighbourhood of the Bembesi Valley has been known since W. H. Kenny, a diamond prospector, brought a number of specimens into the Rhodesian Museum some years ago. He would not state exactly where he had found them, but the impression was gathered that they came from the banks of the Bembesi River itself. This is probably a mistake. In a stretch of twelve miles of the river that I have mapped I have observed no single specimen. Mr. Maufe, moreover, has elicited the fact that many specimens were given to Mr. Kenny by

Mr. Laidley, who collected them in the Muachine (or Macheni) stream on the Hambagahle Farm. This is a very prolific locality, but, since the majority of streams in this neighbourhood are implementiferous, it is not probable that all Mr. Kenny's specimens came from this spot.

Practically all the implements that I have collected were found in banks of sand and stones between bars in the rocky bottoms of streams, and not *in situ* in alluvial gravels, but in some instances there was considerable evidence indicating the alluvial bed from which they were derived, and it was noticed that a stony alluvium overlain by black vlei soil was present wherever implements were to be found. Special features characterise the implements of certain localities, but at other localities a great variety of types was found.

The localities to be described are the following spruits: Powola, Queen's Mine Spruit, and Imbusine, which are tributaries of the Bembesi, Muachine and Kenyani, which flow by way of the Xoce into the Umguza, and the Umguza itself. The most primitive types are yielded by the first two localities.

The Powola rises on the basalt scarp near the Bulawayo-Queen's Mine road, and flows north-westward through a line of vleis which mark the edge of the Forest sandstone as far as the prominent kopje Ilitche, where it bends northward to join the Bembesi five miles further. It is on the Farm Portive, one mile below Ilitche, that the implements are most frequent. They are found over a stretch of about a mile, and are not by any means all of one type. One form, however, which I have not found at any other locality, is fairly common. It has an attenuated point, usually with a medium ridge on one side surface. The massive butt end is roughly shaped to be grasped in the palm of the hand and has no sharpened edge. This type is comparable with the Chellean. Used with a downward blow at close quarters this must have been a formidable weapon. A variety of other types of implement, including "limandes" similar to those of the Imbusine described later, are found in this stretch.

The favourite material for the manufacture of implements in this neighbourhood is a fine-textured felsitic breccia, which breaks with a clean flinty fracture. This rock outcrops about one and a half miles to the east.

The banks of this spruit, six or eight feet high, are composed of black vlei soil, at the base of which is an inconstant bed, sometimes as much as four feet thick, composed of subangular fragments in a muddy or sandy matrix. I have found roughly-worked implements in this bed, but no good specimen *in situ*. There is little reason to doubt, however, that all the specimens came from it, since I was able to find comparatively unworn implements on the same banks in the river bed this year as last.

For want of a better name, the term Queen's Mine Spruit, is applied to a stream which rises on Induna Farm and flows

between the two shafts of the Queen's Mine to join the Bembesi three miles below the Lonely Road. Although I have mapped the whole length of this stream up to the Queen's Mine, I observed implements only at the drift a quarter of a mile from the Bembesi. At this point five implements of somewhat crude workmanship, but similar in form, were found. The implements are composed of a somewhat intractable greenstone, and are pointed and somewhat sharpened at the back, with a tendency to a zigzag ridge on either side. A bed of stony alluvium occurs in the left bank of the stream near the point where the implements were found. Vleis occur along the greater part of its length.

The Muachine rises in the Hibene hills on Mayo Farm and flows over a spur of Forest sandstone on to the schists. Implements are fairly common at a point about a mile above the Lonely Road drift, and again at a point about a mile further up stream, where the basal portion of the sandstone is the bed rock. Near both these points vlei soil with stony alluvium at its base occurs. The implements are rather various, but mostly of both Chellean and Acheulian types. A rather common type is the "cleaver," which has been supposed to be a distinct form. This implement bears a superficial resemblance to an early Bronze Age celt and is carefully worked, with its greatest length perpendicular to a sharp edge. The lateral edges are trimmed by flaking on both sides, but the "cleaver" edge is untrimmed, and formed by the intersection of the fracture which detached the fragment from which the specimen was made from the parent rock and the original surface of the rock itself. The cleavers often appear to be well finished, but Dr. Peringuey's contention, that the form is a stage in the process of manufacture of the limande and not a finished product, is very likely true. The study of a large number of specimens has led me to the conclusion that it was the maker's intention in every case to complete the flaking all the way round.

The implements of the Muachine are all made of local rocks, the most favoured of which is a somewhat carbonated porphyrite in which the pseudomorphs, after the felspar phenocysts weather out on exposure, leave cavities. Implements made of chalcedony or Karroo sandstone are occasionally found.

Very similar implements occur, but less plentifully, in the Kenyani, a stream which joins the right bank of the Xoce three miles above the Muachine.

The Xoce River itself flows in a rocky bed with a fairly steep gradient, and usually without alluvial banks and without vleis. A few worn implements have been found, but they appear to be very rare, and may have been brought down by tributary streams.

In the Umguza River implements are fairly common in a stretch of some twelve miles of this river above the confluence of the Xoce, particularly on the Farms Helenvale

and Dovenby. The river at this point is flanked by great banks of alluvium (described by the writer, "Transactions, Geological Society of South Africa," vol. xix, pp. 29-30, 1916), which was observed at one place to be eighty feet thick. No implements were found in place in this alluvium, in spite of their frequency along the bed of the river, but at one point I found an implement underlying and partly imbedded in a fall of alluvium and black vlei soil in such a way as to suggest that it had come from one of these. Black vlei soil was frequently observed at the top of the cliffs of alluvium.

The implements are largely of Acheulian type, sharpened as carefully at the butt end as at the point. They are frequently so large and clumsy that, when one is gripped in a man's hand of ordinary size, the tips of the fingers and the base of the palm do not reach to the thickest part of the implement, rendering it impossible for the holder to obtain a really effective grip if the instrument is to be used as a knife or for digging. The ungainliness of many of these implements is due to the nature of the material of which they are made. This is commonly silcrete, the surface portion of which does not fracture clearly, and is sometimes left on both sides.

The Imbusine Spruit is perhaps the most interesting locality of all. Within about fifty yards of the reef of the old Imbusine Mine, as usual in the bed of a spruit which is flowing with water pumped from a neighbouring mine, vertical schists rise in bars just above the level of the water, the banks being formed of black vlei with the usual gravelly base resting on the schists. At one point implements were found in profusion between two bars just beneath the water, about a dozen lying in the space of a square yard.

There were five cleavers of the same form as those up the Muachine, showing different degrees of completion. None of them is finished when compared with the best of the limandes, and in none has the square edge been trimmed. The association lends support to Dr. Peringuey's contention mentioned previously.

Of the three pointed implements, only one was finished with any skill.

The majority of these implements are made of a quartz porphyry, which outcrops about one and a half miles up stream. The natural rounded surface of the rocks has been utilised to a great extent in the manufacture of the implements. The whole side of one of the smaller limandes, which cannot be regarded as unfinished, is made up of the natural surface of a boulder.

The interesting feature about this locality is the large proportion of implements of one particular type. Of twenty-eight implements collected, only three are pointed, fifteen are well-made Acheulian limandes, five are cleavers, and the rest are limandes badly made or unfinished.

The limandes are mostly between six and a half and eight inches in length, but some are smaller, down to four and a half inches. None exceed one and three-quarter inches in thickness. The outline is ovate or elliptical, and the edge is sharpened all round. There is no mid-rib on either surface, and when the implement is viewed from the side the edge is approximately straight, the inverted " S " curves frequently seen in European Acheulian implements not being noticeable in these. They are very slightly worn, though weathered, and therefore somewhat soft. It seems probable that they were lying when found on their original floor, and that their former covering has been removed quite recently.

A trench was dug for a distance of about five feet into the bank, in the hope of finding more implements of the same type in place beneath the vlei soil. Two good implements, quite unworn, and some others were found by the boy during my absence near the face of the bank, but the rock floor rose slightly further in, and no stony bed or other implements were found in the deeper part.

In a stretch of the spruit half a mile further up stream, implements of many types are abundant. They are chiefly pointed and of crude workmanship, but two similar to the limandes of the former spot were found, and some flakes and implements worked on one side, only comparable with the Mousterian, but the minute scrapers of the Bushman type are rare here as in the other streams mentioned above.

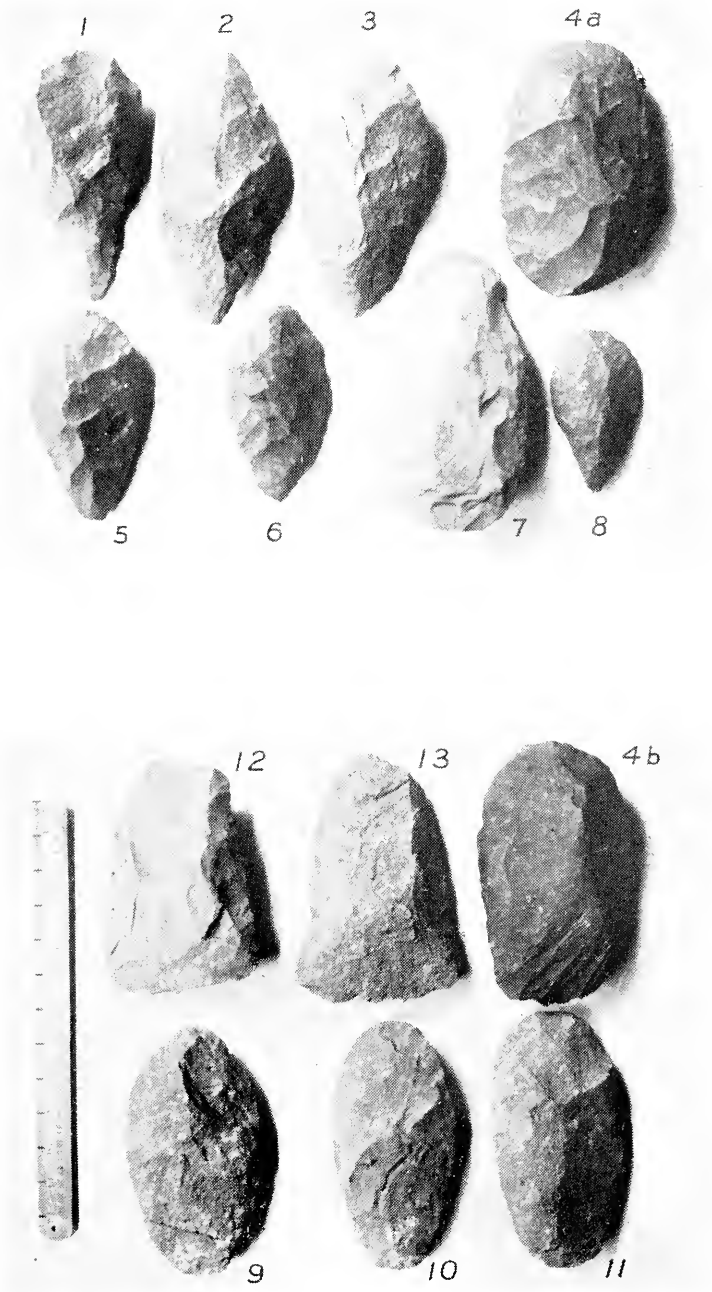
In the upper portion of the Imbusine River, as also in the Tegwan, which joins the Umguza below the confluence of the Xoce, a very large variety of implements occur.

Photographs of some of the implements described in this paper are given on Plate XXX.

The Rhodesian Museum contains a collection made by W. H. Kenny of about a score of implements of a remarkable type, characterised by a very attenuated point with the butt's edge sharpened. It is remarkable that, although I have seen considerably over a hundred large palaeoliths in the field, I have never encountered anything approaching this type. It is probable that the specimens occurred as a single hoard, similar to the one in the Imbusine just described.

In conclusion, it may be stated that certain other streams were mapped in some detail, but were not found to contain stone implements. Of these may be mentioned the Umguza below the confluence of the Xoce, where it flows in a sandy bed between sandy banks, the Xoce and the Bembesi across the Robert Block, besides other parts of the streams already mentioned. Moreover, the larger palaeoliths are very rare on the bare veld.

In every place where implements were found to be abundant, the stream in which they occurred flowed on a rocky bottom between banks of black vlei soil, at the foot of which there was generally a bed of stony alluvium, from which it is presumed that the implements came.



STONE IMPLEMENTS FROM UMGUZA AND BEMBESI VALLEYS.

It appears that the black vlei soil, the method of formation of which has been described by Mr. Maufe, has accumulated since the formation of the older palaeolithic implements, and is now undergoing removal.

EXPLANATION OF PLATE XXX.

STONE IMPLEMENTS FROM THE UMGUZA AND BEMBESI VALLEYS.
(About one-sixth natural size.)

Fig. 1.—Pointed Chellean type, with unsharpened butt, Powola.

Figs. 2, 3, 6.—Pointed Acheulian implements, Tegwan.

Fig. 4 *a* (and *b*).—Two sides of same implements, showing surface (4*b*) detached from parent rock, upper portion of Imbusine.

Figs. 5 and 7.—Acheulian implements, Umguza.

Fig. 8.—Implement from upper part of Imbusine.

Figs. 9, 10, 11.—Ovate implements, Imbusine.

Figs. 12, 13.—" Cleavers," ovate implements unfinished, Macheni.

THE EFFECT OF ELEVATION OF TEMPERATURE AND ALTITUDE OF AERODROME IN THE TAKING OFF OF AEROPLANES.

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Read July 15, 1920.

INTRODUCTION.

The Cairo-Cape flights of the present year brought into prominence many peculiarities of conditions arising from the high temperature combined with high altitude of the aerodromes on the route. The conditions were for the most part new, for flight from elevated aerodromes in Europe and the United States has been made as a rule in temperate climates, where the temperature at such altitude was low. These peculiarities, which led to great difficulties for the pilots, may be divided into two classes:—

(1) Engine peculiarities, especially defects of carburation and unequal heating of the cylinder jackets owing to the high temperature of the air.

(2) Aerodynamical peculiarities, owing to the tenuity of the atmosphere.

In the former class the difficulties were not to be foreseen, and much valuable information has been obtained as a result of these flights.

The latter class of difficulty, on the other hand, was one that could have been predicted with certainty by anyone who has had experience in the testing of the performance of aeroplanes under varying conditions of the atmosphere. Much trouble would have been saved if some figures had been worked out beforehand as to the maximum load per horse power allowable under the unfavourable conditions of low air density to be expected in the hot and high tableland of Central Africa.

As Rhodesia and the greater part of the Union of South Africa offer the disadvantageous conditions of high ground, often at elevated temperature, it seems worth while to consider in what way the ideas of aviation as obtained from experience in Europe must be modified when applied to this country.

I.—The Effect of Temperature and Altitude.

As a result of a vast amount of investigation with the greatest possible variety of machine during the late war, the performance of a machine in the air can be predicted with a very fair amount of accuracy. The factors which determine the air speed on the level and the rate of climb are:—

(1) The loading in pounds per horse power.

(2) The wing-loading in pounds per square foot.

(3) The density of the air.

(4) The propeller efficiency, *i.e.*, the proportion of the horse power which is used in propelling the machine.

When these factors are taken into account, the performance of all machines, from the lightest scout to the heaviest bomber, seem to fall into the same scheme.

The propeller efficiency is the most uncertain term in the work. It may reach about 70 per cent., but the efficiency depends on the air speed, and at the slow speeds of running along the ground before taking off it certainly will be considerably lower than this figure.

The most serious effect of a diminished density is in lowering the horse power of the engine. At each stroke a smaller mass of air is drawn in. Though an "altitude control" may correct the consequent over-richness of the mixture, nothing but a motor compressor or similar contrivance will obviate the reduction of energy supplied by each stroke.

The following calculations are based on figures of reduction of horse power with density used in dealing with performance tests during the war. I understand that these figures are considered to be too optimistic, but, as it is my object to give a lower limit to the effect sought, the values are in the right direction, and at any rate are not exaggerations.

It is often stated that the tenuity of the atmosphere makes flying difficult, because the air is "too thin to hold up the machine." This is erroneous in the sense usually intended. The thinness of the air also diminishes the resistance to the forward motion of the machine, and the greater air speed thereby obtained compensates for the loss of lifting power at a given speed. By far the most important effect is that of reducing the engine power.

The density of the air can be calculated when the pressure and temperature are known. In the following work the conditions are taken at 3,000, 4,000, 5,000 and 6,000 feet altitude, and temperatures 50, 60, 70, 80, 90, 100 degrees Fahrenheit. The altitudes are what are called "isothermal heights," *i.e.*, heights as given by an ordinary aneroid or altimeter.

The curves of Fig. 1 show the engine factor $f\ (d)$ which must be used to multiply the horse power at sea-level for the same number of revolutions per minute to get the horse power actually obtained. d = the density of air compared with that at sea-level under standard conditions (*i.e.*, 1,222 grammes per cubic metre).

The greatest possible varieties of machines with different loadings and in air of different densities have performances which fit into the two curves given in Figs. 2 and 3 fairly well.

In Fig. 2 the abscissa is $E_0 \sqrt{d}\ f\ (d) \sqrt{7/w}$, and the ordinate $V \sqrt{d} \sqrt{7/w}$.

In Fig. 3 the abscissa is $E_0 \sqrt{d}\ f\ (d) \sqrt{7/w}$, and the ordinate $v \sqrt{d} \sqrt{7/w}$.

Where

E_0 = engine horse power per 1,000 lbs. of load.
d = density relative to air at sea-level.
w = wing-loading in lbs. per square foot.
V = level speed (air speed) in miles per hour.
v = rate of climb in feet per minute.

It is from these figures that the following work is calculated. The way in which the density and loading come into the above quantities is the result of elementary aerodynamical theory.*

The points shown in Figs. 2 and 3 are calculated from actual tests on Vickers-Vimy bombers and D.H.9 machines.

* L. Bairstow, "Applied Aerodynamics."

II.—Length of Run on Ground Before Taking Off.

Perhaps the most striking change which a pilot used to European conditions will notice in flying here is the greater run required to take off. Especially is this the case when the machine is heavily loaded and the air is hot. Lieut.-Colonel Sir H. A. van Ryneveld refers repeatedly in his technical report* to the difficulty of taking off his heavily-loaded machine:—

> " . . . . had to cut down more trees, Shirati, to take off."
>
> " Abercorn.—Only possible and safe take off here is before sunrise, down slope, whatever wind."
>
> " Unexpected difficulties taking off, due altitude and comparatively high temperature and moist atmosphere." (At Livingstone.)
>
> " Every take off Northern Rhodesia was touch and go for the first few minutes, tail skid scraping trees."

And so on.

The following theoretical considerations will enable us to estimate the effect of altitude and temperature (*i.e.*, lowness of density) on the length of run to take off. The least favourable case of no wind is taken.

We can divide the run to take off into two portions:—

(1) A run with tail down until some speed—say 20 miles per hour—is obtained. This distance, which is quite short, will be unaffected by the density of the air. The speed is too slow for the air resistance to play an important part.

(2) A run with tail up, in which the speed rises from 20 miles per hour to the flying speed. This is by far the more important and greater portion of the run. We will assume that the pilot takes off at the minimum flying speed, and that we may neglect the frictional forces connected with the contact with the ground. In this way we shall get an underestimate of the length of the run required, for he will probably not lift the machine from the ground until he has some slight reserve of speed over the minimum flying speed.

Let s = the distance of the run from the place where the speed is 20 miles per hour.

P = the horse power of the engine.

η = propeller efficiency.

v = speed in feet per second.

m = mass of the machine in pounds.

g = 32·2 feet per second per second.

Then, thrust − resistance = mass × acceleration.

* "The Aeroplane," vol. xviii. 13. p. 670.

The thrust is $\frac{\eta\, 550\, P}{v}$. Resistance $= K\, d\, v^2$.

$$\frac{\eta\, 550\, P}{v} - K\, d\, v^2 = \frac{m}{g} - v\, \frac{dv}{ds}. \qquad (1)$$

To find K, we will assume that the machine in the tail-up position is in the attitude for level flight, for which the air speed is l ft./sec.

Then
$$\frac{\eta\, 550\, P}{l} = K\, d\, l^2,$$

$$\eta\, 550\, P\, (1 - v^3/l^3) = m/g\, v^2\, \frac{dv}{ds}.$$

This leads to
$$s = \frac{m}{g.\ \eta.\ 550.\ P} \left(\frac{l^3}{3}\right) ln \left(\frac{1 - 20^3/V^3}{1 - V_0{}^3/V^3}\right)$$
$$= \frac{0.1368\, V^3}{\eta \quad E} \log. \left(\frac{V^3 - 20^3}{V^3 - V_0{}^3}\right).$$

Where V = level speed in miles per hour.

V_0 = minimum flying speed in miles per hour.

E = horse power per 1,000 lbs.

In this formula, V and E both diminish with diminishing density, but the change of V is small compared with that of E. V_0, on the other hand, increases as the density gets less, being proportional to $\frac{1}{\sqrt{d}}$.

When $V_0 = V$, *i.e.*, at the ceiling, the length of run becomes infinite.

III.—Application to the "Silver Queen II." (Vickers-Vimy Machine.)

The weight of the Vickers-Vimy machine, without load, is only known to me when the engines were Sunbeam Morris. The difference in weight of these engines from that of the Rolls-Royce Eagle VIII. is known, and the weight I have taken cannot be far from correct.

I have taken two loadings, as follows:—

(1).

Machine, light	6,900
Fuel and oil	1,200
Crew and accessories	720
Total weight	8,820 lbs.

(2).

Machine, light	6,900
400 gallons petrol	2,880
30 gallons oil	270
Crew, spares, etc.	950
Total weight	11,000 lbs.

As far as report goes, the latter must have been about the load with which Lieut.-Colonel Sir H. A. van Ryneveld left the Bulawayo Aerodrome with the "Silver Queen II." on its last flight.

The former load we speak of as a "light load." It represents petrol for about three and a half hours' flight calculated from the average rate of consumption given by Lieut. Colonel Sir H. A. van Ryneveld, viz., 40 gallons an hour.

For the purpose of calculating the horse power, it is necessary to take the rate of revolutions per minute into account. I have taken 1,550 revolutions per minute for this. For this rate the horse power of each engine at sea-level (density 1) is 315, as given by average bench tests. As the revolution per minute will be lower than this for the early part of the run, we shall get for this reason again an underestimate of the run required.

The wing area (lifting surface) of the machine is 1,387 square feet. We have therefore for the two cases:—

Light load, $E_0 = 71{\cdot}5$, $w = 6{\cdot}36$ lbs. per square foot.

Heavy load, $E_0 = 57{\cdot}3$, $w = 7{\cdot}94$ lbs. per square foot.

E_0 = engine horse power per 1,000 lbs. at sea-level.

w = wing-loading.

Another factor in making the calculation is the landing speed, or minimum flying speed. This (as in the case of all air speeds considered) is the true air speed, *i.e.*, the indicated air speed divided by $\sqrt{d}$. I believe that 60 miles per hour will be a fair estimate to take for the light load at sea-level. The correctness of this figure will not greatly affect the comparison of the different conditions. With variation of the conditions, this speed will be proportional to the square root of the wing-loading, and inversely as the square root of the density. The greater speed to take off with diminished density and increased loading will have a marked effect in lengthening the run.

The propeller efficiency, as remarked above, is the most uncertain term. It attains the value of 70 per cent. at the best speed for the propeller, but in the low speeds of run along the ground it will certainly be less than this. For purposes of comparison its value does not matter. We will take it 60 per cent., which is probably a good deal too high for the early part of the run.

With the above data we can calculate the minimum run to take off at sea-level and at the different altitudes and temperatures.

Table I.

Light load. Total weight 8,820 lbs. Run to take off in feet: at sea-level, 321 feet.

Temperature.	Altitude.			
	3,000 Feet.	4,000 Feet.	5,000 Feet.	6,000 Feet.
50° F.	418	461	513	570
60° F.	436	486	541	602
70° F.	461	519	570	639
80° F.	486	542	603	674
90° F.	514	574	637	711
100° F.	542	604	674	750

Table II.

Light load. Ratio of run to that required at sea-level.

Temperature.	Altitude.			
	3,000 Feet.	4,000 Feet.	5,000 Feet.	6,000 Feet.
50° F.	1·30	1·44	1·60	1·78
60° F.	1·36	1·51	1·69	1·88
70° F.	1·44	1·62	1·78	1·99
80° F.	1·51	1·69	1·88	2·10
90° F.	1·60	1·79	1·98	2·22
100° F.	1·69	1·88	2·10	2·34

Table III.

Heavy load. Total weight 11,000 lbs. Run to take off in feet: at sea-level, 601 feet.

Temperature.	Altitude.			
	3,000 Feet.	4,000 Feet.	5,000 Feet.	6,000 Feet.
50° F.	796	885	994	1,124
60° F.	832	935	1,046	1,193
70° F.	880	991	1,117	1,268
80° F.	934	1,050	1,190	1,352
90° F.	990	1,117	1,263	1,443
100° F.	1,050	1,191	1,341	1,542

TABLE IV.

Heavy load. Ratio of run to that required at sea-level.

Temperature.	Altitude. 3,000 Feet.	4,000 Feet.	5,000 Feet.	6,000 Feet.
50° F.	1·32	1·47	1·66	1·87
60° F.	1·39	1·56	1·74	1·99
70° F.	1·46	1·65	1·86	2·11
80° F.	1·55	1·75	1·98	2·25
90° F.	1·65	1·86	2·11	2·40
100 F.	1·75	1·98	2·23	2·55

From the above results we see that at Bulawayo, for example, with a temperature of 90° F., an aerodrome in every direction nearly twice as large as under ordinary European conditions would be required; while at places of altitude 6,000 feet with a temperature of 100° F. the linear dimensions of the aerodrome should be two and a half times those of the aerodrome in England required for the same machine.

IV.—RATE OF CLIMB FROM THE AERODROME.

Hardly second in importance to the length of run to take off is the rate at which the machine will climb out of the aerodrome. Not only has it to clear obstacles such as trees on the boundary, but it must rise sufficiently high to be out of the disturbed condition of the atmosphere in the neighbourhood of surrounding hills and kopjes. The rate of climb under different conditions of altitude and temperature can be calculated from the curve in Fig. 3. In Figs. 4, 5, 6, 7 we have the curves giving the rate of climb for any ground horse power per thousand pounds and for the six different temperatures and four different altitudes, the curve for sea-level being given in each case for purposes of comparison.

Calculation of the rate of climb under the different conditions leads to the following results:—

TABLE V.

Vickers-Vimy. Light load. Total weight=8,820 lbs. Rate of climb in feet per minute: at sea-level, 845 feet per minute.

Temperature.	Altitude. 3,000 Feet.	4,000 Feet.	5,000 Feet.	6,000 Feet.
50 F.	696	648	597	543
60° F.	674	619	568	516
70° F.	648	597	542	487
80 F.	619	568	516	464
90 F.	597	542	486	438
100 F.	568	515	463	417

TABLE VI.

Vickers-Vimy. Heavy load. Total weight = 11,000 lbs. Rate of climb in feet per minute: at sea-level, 523 feet per minute.

Temperature.	Altitude.			
	3,000 Feet.	4,000 Feet.	5,000 Feet.	6,000 Feet.
50° F.	396	360	312	267
60° F.	377	332	290	243
70° F.	358	308	265	221
80° F.	332	288	244	201
90° F.	308	265	222	180
100° F.	288	244	201	162

For purposes of comparison we may take the results for the D.H.9 machine with the Siddeley Puma engine ("Voortrekker"). The loading is taken as follows:—

Machine, light	2,200
Fuel and oil	500
Crew, etc.	360
Total weight	3,060 lbs.

Wing area, 436 square feet. Revolutions per minute, 1,350. Horse power (sea-level), 242. Horse power per 1,000 lbs., 79·1. Wing-loading, 7 lbs. per square foot.

TABLE VII.

"Voortrekker." Rate of climb in feet per minute: at sea-level, 965 feet per minute.

Temperature.	Altitude.			
	3,000 Feet.	4,000 Feet.	5,000 Feet.	6,000 Feet.
50° F.	800	740	688	626
60° F.	772	715	662	600
70° F.	740	685	636	568
80° F.	712	655	608	542
90° F.	685	628	568	518
100° F.	660	600	542	500

It will be seen that the rate of climb of the Vickers machine loaded as it left Bulawayo falls to a very low value for high altitudes and high temperatures. Taking the

extreme case of 6,000 feet at 100° F., the rate of climb is only 162 feet per minute. It is also clear that the superior performance of the "Voortrekker," which finished the flight to Capetown, is not due, as was supposed by some, to superiority of the machine or its engine, but merely to the fact that its loading was more suitably tempered to the disadvantageous conditions of altitude and temperature.

V.—Effect of Humidity.

It is worth while considering the effect of water vapour in the air on the performance of the machine. For a given pressure the amount of dry air in a given volume diminishes with increase of humidity, and the effect, unimportant at low temperatures, might become important at high temperatures. For example, saturation at 100° F. will decrease the relative density of the dry air from 0·746 at 6,000 feet to 0·689, a change of 7·6 per cent. The factor of reduction of engine power is thereby reduced from 0·736 to 0·677, a reduction of 8 per cent. The relative density of the dry air is what must be used in the engine factor, since the vapour drawn in at each stroke is passive as far as combustion is concerned. On the other hand, the aerodynamic effect of humidity is negligible, the square root of the density being very little altered by the presence of water vapour. In Fig. 1 the alteration of engine power factor for presence of saturated water vapour is shown.

It appears as if even the extreme case of saturation at 100° F. would only produce about 8 per cent. increase in the run to take off.

It does not appear therefore that (apart from the effect on the fabric and the extra weight due to deposition) humidity should have much detrimental effect on the performance of the aeroplane.

VI.—Conclusion.

It is clear from the above considerations that the views as to possible loading per horse power gained from experience during the war, more particularly from bombing machines, must be modified when applied to flight in Central and South Africa. One of three courses is open: Either (1) our aerodromes must be made larger (say twice as big as under European conditions); or (2) the loading of the machines in pounds per horse power must be considerably reduced; or (3) some effective way of overcoming the loss of horse power with diminished density must be employed.

With regard to (2), long non-stop flights must give place to shorter flights of three or four hundred miles or less.

Thereby the load of petrol may be reduced and smaller machines may be used.*

With regard to (3), as far as I know, all such devices of forced draught into the engine that have been tried under European conditions have not been found to give extra horse power commensurate with their extra weight. It is, however, a question worthy of consideration whether under the different conditions of this country some such device may not be worth while adopting.

* It is interesting to compare the recent flight of Mr. Bert Hinkler on his Baby Avro (35 h.p. Green engine) from London to Turin without a stop. The distance (650 miles) is about the same as the Bulawayo-Pretoria stretch. On this wonderful flight, which included the crossing of the Alps, 25 gallons of petrol were carried and only 20 gallons used. Compare this with the 400 gallons of petrol on the Bulawayo flight.

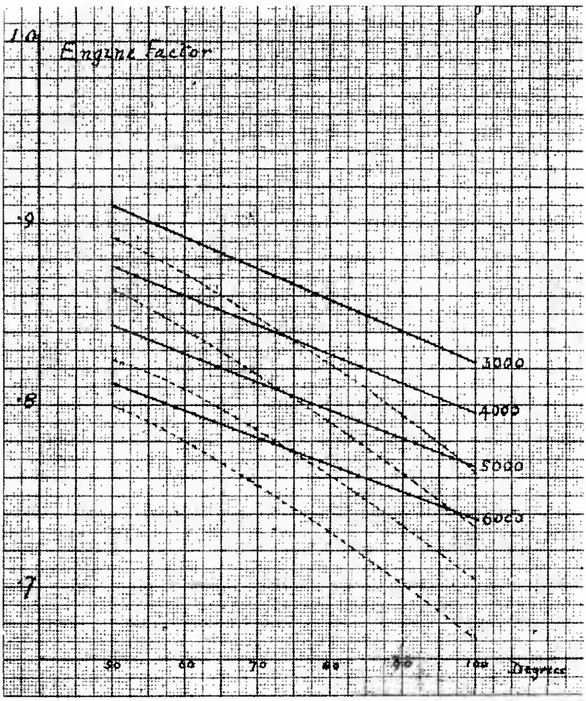


Fig. 1.

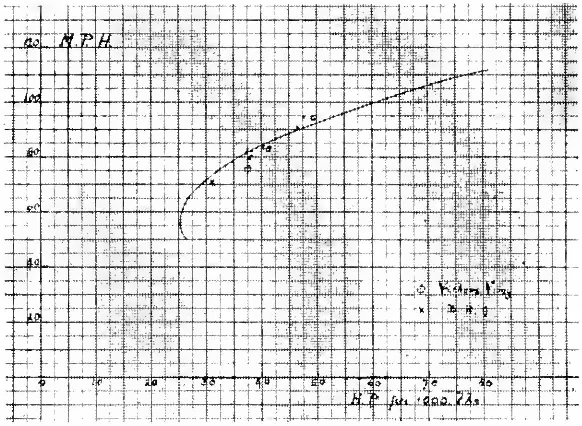
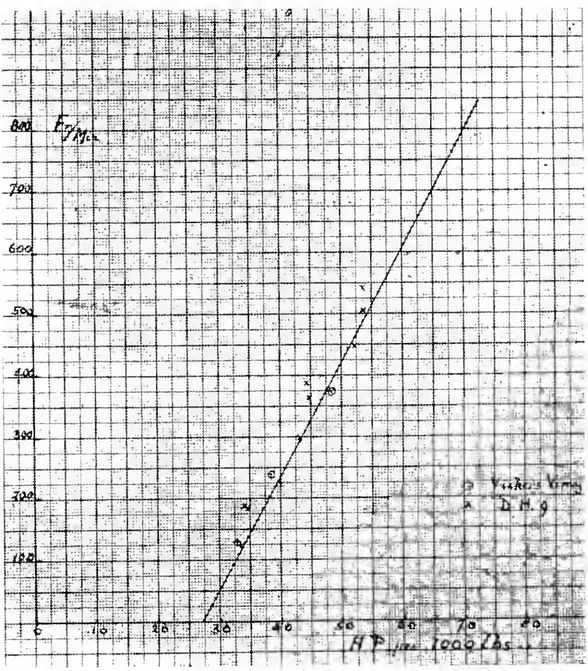

M.P.H.
120
100
80
60
40
20
0
10
20
30
40
50
60
70
80
H.P. per 1000 lbs.

Fig. 2.


800
700
600
500
400
300
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50
60
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H.P. per 1000 lbs.
D.H.9

Fig. 3.

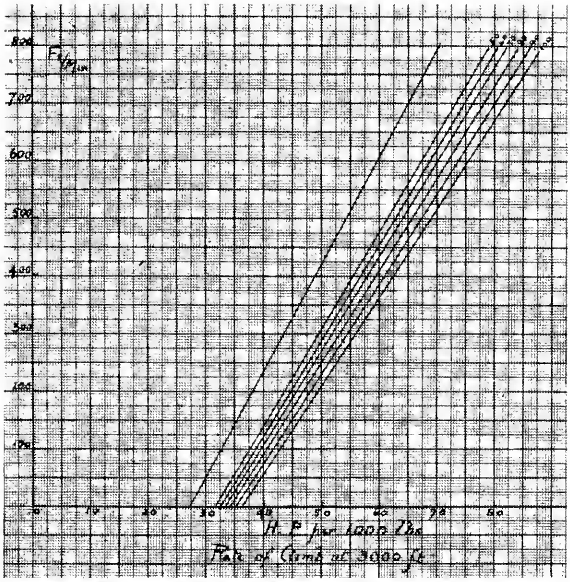
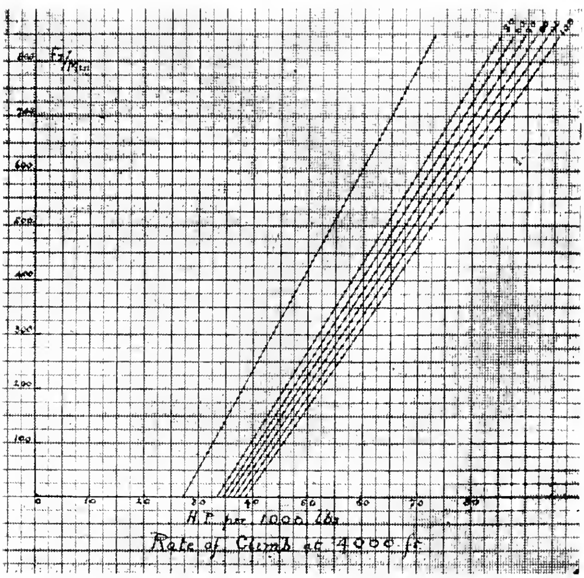

Ft/Min
800
700
600
500
400
300
200
100
0
10
20
30
40
50
60
70
80
H. P. per 1000 lbs
Rate of Climb at 3000 ft

Fig. 4.


Ft/Min
800
700
600
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50
60
70
80
H.P. per 1000 lbs
Rate of Climb at 4000 ft

Fig. 5.

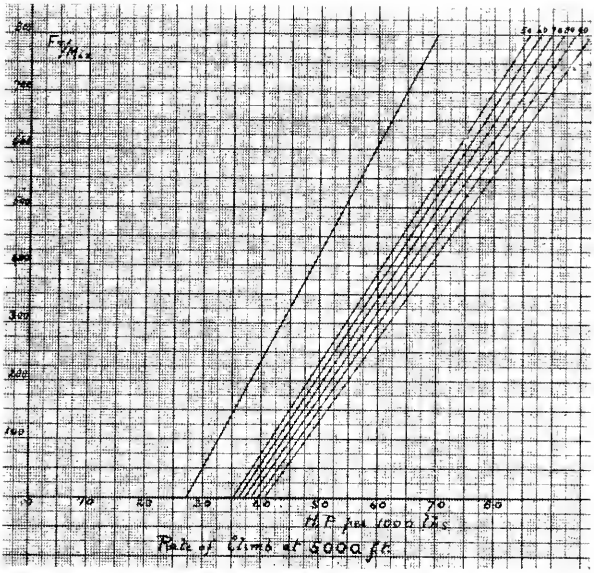
Ft/Min
H.P. per 1000 lbs
Rate of Climb at 5000 ft.

Fig. 6.

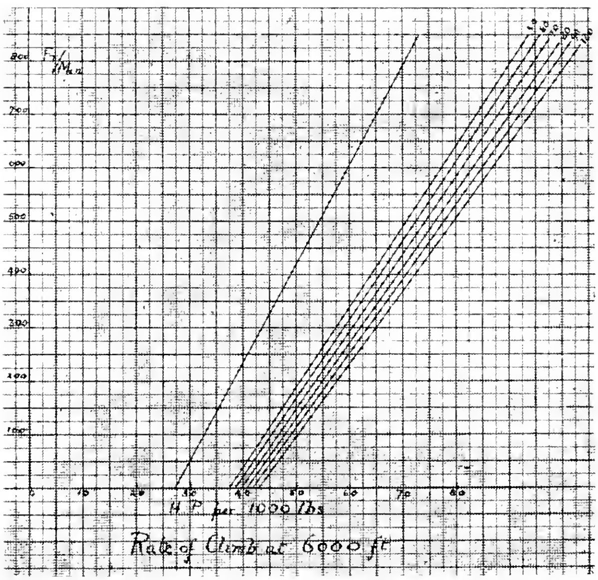
Ft/Min
H.P. per 1000 lbs
Rate of Climb at 6000 ft

Fig. 7.

KARROO ROCKS IN THE MAFUNGABUSI, SOUTHERN RHODESIA.

By A. J. C. Molyneux, F.G.S.

With Three Text Figures.

Read July 15, 1920.

I.—Introduction.

The distribution of Karroo rocks in the Mafungabusi and the conditions under which they were accumulated are frequently found to be matters on which some information is desirable, in order that a comparison may be made with the succession of the same system of rocks in the Wankie coalfield (3)* some 160 miles to the west, and with the Upper Karroo strata to the north-west of Bulawayo (4 and 5), which are the only localities that have been mapped by the Geological Survey in detail. A part of the Mafungabusi is included in the traverses that formed the basis of the introductory paper to the geology of the region by the writer in 1903 (1), while Mr. C. E. Parsons in 1903 gave a section, with notes of a route he had made from Gwelo to the Zambezi.

As the writer had made journeys across the region many years ago and taken route maps and geological notes on each occasion it has been suggested that he should look up these records for publication. Fragmentary as each single section must be owing to the circumstances in which it was made, the piecing together of the whole presents evidence on which the conclusions around it in this paper may be reasonably based. But it is not presented as being incapable of error.

II.—Physical Features.

The region known as the Mafungabusi lies in the Zambezi basin and on the west of the Umniati River.† It includes the head-streams of the Sesami and Bume Rivers, flowing north-north-west, the Ngondomo vlei circling round the south, and several eastward running tributaries of the Umniati, namely, the Mzongwe, Nyoripakwe and Paruka. Cartographically it is placed between 17° 40′ 00″ S. and 18° 20′ 00″ S., while the meridian of 28° 45′ 00″ E. cuts through its centre.

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* The numbers in brackets refer to the papers listed in the References at the end of this memoir. These papers are discussed in Section V of this memoir.

† In many Rhodesian rivers the name applied to different parts of its course varies. This river is known as Umniati as far as its confluence with the Umfuli, then as the Sanyati. Ume, Bume and Ome (Omay) are local terms for the other river referred to.

The name is, however, more generally applied to the remnant of a dissected tableland of sedimentary and volcanic rocks that in the south overlap on to the uplands of crystalline schists, the northern margin being defined by an escarpment

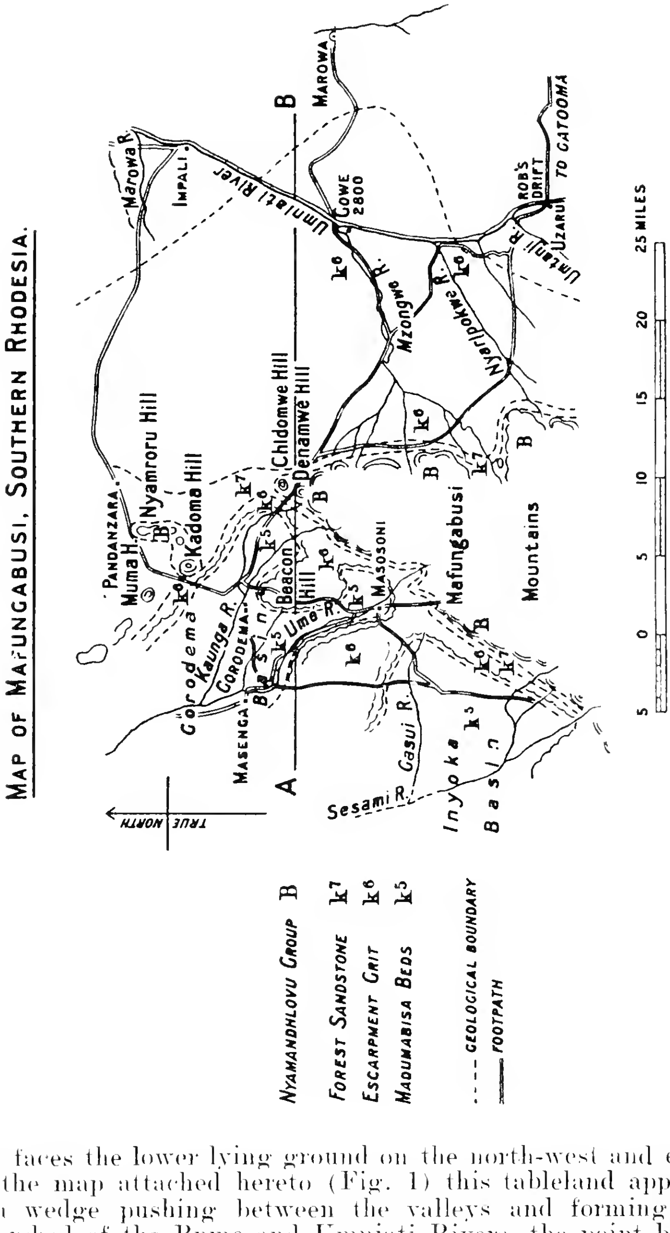


Fig. 1.

that faces the lower lying ground on the north-west and east. On the map attached hereto (Fig. 1) this tableland appears as a wedge pushing between the valleys and forming the watershed of the Bume and Umniati Rivers, the point being

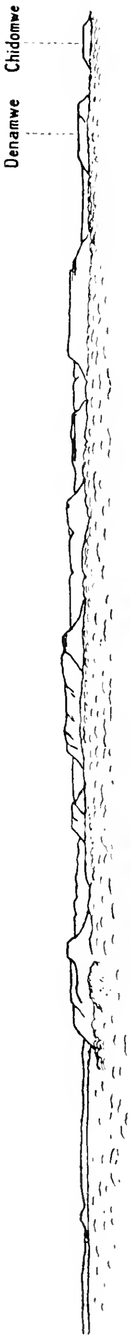
formed by a conical hall, named Chidomwe, and which is separated by a wind-gap from the larger Denamwe Hill. A broken chain of flat-topped outliers of mesa type, extending eighteen miles to the north-west, shows that once the tableland continued over a considerable region in that direction, but which has since been cut back by erosion to the line of its present margin, that now stretches many miles to the south-west, where it had been previously mapped by me as the "Great Escarpment" (1). This feature includes the Mafungabusi Mountain, the wedge-shaped block described above. A view of the eastern side of this dissected plateau, taken from the Mzongwe Drift, is given in Fig. 2.

To the north-north-east of the mountain the flat country is continuous, with wide mopani forests and baobabs. The soil is deep and cold, and there are frequent patches of well-rounded pebbles and occasional pans. The area seems to be a plain that has resulted from the disintegration and denudation of Karroo beds. Pre-Karroo sedimentary rocks appear in the Umniati around Impali village and at the junction of the Umtanji, and form the floor of the Karroo area in this vicinity.

West of the mountains there is a great change from the above-mentioned conditions. Erosion is here relative to the Bume River sytem, 2,600 feet in altitude in the basin around Gorodema, or to the Sesami River system in the Inyoka country, and in both of which it has denuded the Matabola beds, so that there are exposed large areas of clays and coals. These rocks give rise to the cold, sun-cracked soils so favoured by mopani forests, or covered by short thorn and a species of burr or "rats-bane." Alluvial deposits in the river banks and creeks are favourable to rich jungle growth, but under cultivation these patches produce good crops of corn and tobacco. Soils from the basaltic rocks and the lighter sandy ground from the Forest sandstone are clad with almost impenetrable brakes and baobab trees, but when put to the test and cultivated, as by the Inyoka Tobacco Company, yield very fine tobacco. Native-grown "Inyoka tobacco" put up into conical loaves, has long been desired by the Matabele. The lower altitude and the shutting off by the mountains of the cool south-east breeze of the plateau seem to account for the climatic change necessary to a more tropical botanical development.

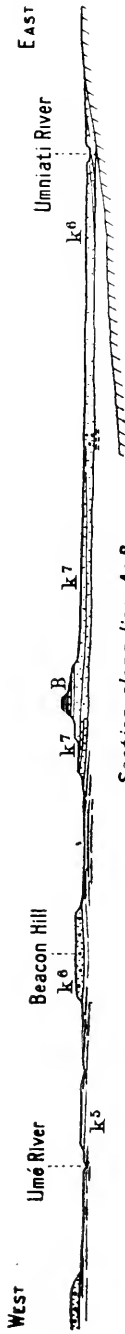
Many permanent springs emerge at the base of the basalt, but the water is absorbed into sandy stream courses after passing but a short distance.

There were at one time several wagon roads into the neighbourhood, but they are fallen into disuse owing to the prevalence of the tsetse fly. Rob's Drift, on the Umniati, is the terminus of a road from Gatooma. In the absence of roads, travellers have to make use of the native footpaths, and those which were traversed by the writer are marked in the map.



PANORAMIC VIEW OF THE MAFUNGABUSI MOUNTAINS FROM THE EAST

Fig. 2.



Section along line **A-B**

Fig. 3.

III.—Footpath Notes.

On approaching the Umniati River, at the Mzongwe confluence from the east, the flatness of the country it here drains is very evident. It is clad by mopani trees of big girth, long grass and knob-thorns, forests of igonti and open glades or dambos. Four miles east of the river is the first indication of the Karroo boundary in an outcrop of angular grit (1268)* and many loose pebbles. In the river itself, here half a mile wide, a resemblance to the Escarpment grit is evident in a mass of felspathic coarse sandstone, holding pebbles of quartz and quartzite, both well rounded and sub-angular in shape.

A similar grit also appears in the position of an overlap on the pre-Karroo floor at the confluence of the Nyaripakwe and Umniati—the bed of the smaller stream showing a mass of grit with pebbles of sharp white quartz only, and of pea and haricot size. Separated from it on the south by a ridge of schist three miles wide is a mass of grit and a thin bed of pebble conglomerate of fragments of quartz and red banded-ironstone. A pre-Karroo conglomerate (1329, 1331) outcrops to the south of this occurrence, and strikes N. 40 E. with a dip of 60 degrees to the north-west.

Six miles up the Mzongwe is a cliff showing 20 feet of coarse, gritty sandstone, irregularly jointed and overlying, in descending order the following: Light yellow clay, 1 foot; pink or French grey shale, 3 feet; grey clay, 2 feet; grey shale, with carbonaceous matter on some layers, the bottom not being seen (1269/72). Reniform nodules of argillaceous ironstone weather out of the shales (*cf. infra*). The beds dip slightly to the south-west, and seem to belong to the highest Matabola beds, and are the lowest strata laid bare on the Umniati side of the mountains. They indicate a pre-Karroo basin to the west deep enough for the deposition of the Matabola beds, the edge of the depression being covered by an overlap of what was probably the Escarpment beds (Fig. 3).

Taking the path from the Mzongwe to Gorodema one passes over a gritty soil and flat country until one rises over broken-down grits and Forest sandstone to the poort between Denamwe and Chidomwe, where there is an interbedded sheet of basalt overlain by a red sandstone of Nyamandhlovu type. Another basaltic sheet forms the summit of the tableland. Descending towards the Gorodema basin the lower basalt (1327) is seen to overlie fine flaggy red and white and sharp-grained transition sandstones (1325) with, underneath, a soft pinkish sandstone with typical white siliceous concretions and kernels (1326) that are doubtless of Forest sandstone position. These fine beds form terraces in front of the major escarpment and its talus of basalt. The path descends further and crosses a raised area of pebbles that must represent an outcrop of the

* High numbers refer to rock specimens in the author's collections

Escarpment grits (compare Beacon Hill, *seq.*), and emerges on to flats of starchy clay shales and coaly shale beds, with many exposed nodular masses of red ironstone of septarian form. These masses are a great feature of the Matabola beds in the Gorodema basin.

Escarpment grits, such as the above, form a terrace or minor tableland around Masosoni in front of the foot of basalt-capped cliffs, and include pebble beds and coarse red sandstone, the latter of which sometimes weathers in reniform and mamillary shapes through the cementing together of sand grains on the oxidation of iron. Through this minor tableland the Bume has trenched down to the underlying beds of clays and coal seams, so that a conformable succession is apparent. On the south slope of Beacon Hill some development of the seams was carried out in 1911, but the quality of the coal was not considered satisfactory. Immediately under the grit are some 116 feet of clays, weathering with starchy fracture, sometimes carrying thin beds of gypsum and being underlain by the coal-shale, coal and clay series of 130 feet, unbottomed.

From Masosoni there is a path going south to Sikonyaula. After leaving the Bume River one rises over marly clays containing silicified wood to a considerable thickness of the Escapment grits series. The highest bed is a loosely coherent felspathic grit, weathering in red iron-cemented aggregates of sand, with a few angular pebbles of a size up to half an inch. The contact with the overlying Forest sandstone is conformable—the bed immediately superposed being a whitish very fine sandstone covered by a red sandstone. The latter is considerably veined in the reticulate form described at Tuli and Gwampa (1) and at Pasipas (5).

The basalt capping is over 125 feet in thickness (the top not being seen), the path running in a depression between higher hills of it. The probability that it lies in two sheets was arrived at by finding amidst the talus slopes lumps of red indurated sandstone with adhering fragments of scoriaceous basalt resembling the interbedded sandstone found in the Nyamandhlovu series on Chelmer farm, near Pasipas (5). Displaced boulders of basalt rock of vesicular character were found on the talus slopes.

Another route into the Gorodema basin is from Impali on the Umniati across the flats to Pandonzara village. The path then goes between the two flat-topped outliers of Kadoma and Muma, and descends past deep nullahs cut into soft beds of a grey sandstone, which is made up of quartz and felspathic interstitial matter and flinty segregations of red shade (1324) that strew the surface, all of which are typical of beds of Forest sandstone. There is also an intercalated bed of unsorted grit of quartz and quartzite grains up to the size of peas, with fragments of angular felspar. Continuing the descent to Gorodema, although no point of contact was noticed, my

notes state that the above beds are underlain by conglomerates that disintegrate and form wide deposits of shingle, with red ferruginous grit and hard red ferruginous sandstone, indicating Escarpment grit. Under them are the clays of the Matabola beds.

IV.—Table of Formations.

Assuming the correctness of these notes, the rocks of the portion of the Mafungabusi region under notice fall into the following table:—

		Thickness in Feet.	Symbol on Map.
Nyamandhlovu Group	Basalt 11 Sandstone 11 Basalt 1 Transition sandstone 1	About 200 feet	B
Forest Sandstone Group	Upper division (siliceous) Fine white and pink sandstone and opaline rods	60–100 feet	k^7
	Middle division Lower division (calcareous)	Not seen or represented	
Escarpment Grit Group	Coarse grits and conglomerates	Minimum 100 feet	k^6
Madumabisa Shales (Upper Matabola Beds)	Grey clays, fissile shales and coals Ironstone nodules Cone in cone limestone Lower groups not seen	Minimum 320 feet	k^5

V.—Summary of the Notes.

Nyamandhlovu Group.—That a sandstone is interbedded in the basalts of the Mafungabusi was first noticed by Mr. C. E. Parsons (2), who gave it as roughly five to ten feet in thickness. Measurements obtained in the Pasipas area, near Bulawayo, show that the corresponding sedimentary beds are not much thicker and that the outcrop may be masked by

falling boulders in the talus of the basalt. Such masking is the case on the Chidomwe Pass and on the Masasoni-Sikonyaula path, though it is fairly conclusive that the basalt is divided into two sheets in these localities.

These sheets are the extension of that known as the Sikonyaula (2, p. 270, also 5, p. 49) to the west of the area under discussion. The approximate thickness of the first and second basalts, including the sandstones (11) is there 250 feet —figures which nearly agree with the approximate thickness in the country to the north-west of Bulawayo around Nyamandhlovu.

It is not possible to say whether this area of basalt connected at any time with that at Nyamandhlovu, to be subsequently separated by the erosion of the Shangani and Gwelo rivers. Much of the country between the two regions is covered by later Kalahari sand, which hides the formations on which it rests.

The transition sandstone, immediately underlying the basalt, corresponds with that occurring to the north-west of Bulawayo in its false bedding, small percentage of interstitial cement and rounded nature of the sand grains. It shows at places extensive shatter belts, subsequently silicified, so that the rock has a network appearance. Reticulate patches are a common feature in these rocks, and have been noted at Pasipas (5, p. 44), Tuli (1, p. 274), and Gwampa (1, p. 278).

The Forest Sandstone is represented by the upper (siliceous) division only, the lower (calcareous) division not having been seen. The number of residuary rods and kernels of silica lying on the surface is very noticeable and helps in demarking boundaries. The group includes an unsorted gritty and pebble layer below Kadoma Hill. The thickness does not exceed 100 feet, while at Pasipas it is about 70 feet.

The *Escarpment Grits* form large red flat-topped hills or minor escarpments from which the Forest sandstone has been removed. They include large areas of pebble conglomerate, flaggy sandstone and red grits, and immediately overlie the Matabola or Madumabisa shales. Pellets of clay are frequently included in the sandstone. Their minimum thickness is 100 feet, but probably some incoherent and overlying beds have been washed away. Mr. Lightfoot (3) gives the figure of 300 feet as the thickness at Wankie.

The Madumabisa Shales of Lightfoot have so much in common with the Matabola beds of the writer that there need be no hesitation in applying the former term to the beds underlying the Escarpment grit. One notable feature, however, is the local absence of nodules of lime, but in the concretions of iron that are probably limestones replaced by metasomatosis, the gypsum, the buff and grey shales, and the presence of thin impure coal beds the evidence seems to be

sufficient for correlation. Cone in cone limestone beds occurs near the Gasue River and at Masenga in the Bume. A borehole was put down in Matabola beds in the Inyoka basin in 1899. It commenced at the foot of a hill of grit and conglomerate overlying shales and clays of coal beds that continued to 310 feet, when they changed at 316 feet to fine grey sandstone with specks of carbonaceous matter and pyritic concretions two inches across. Coarse sandstone and grit, angular and micaceous supervened to 319 feet, below which the rock would not core. This might be relative to the Upper Wankie sandstone.

The nodular ironstones in these beds lie in deep red masses of turtle shape, 10 feet in diameter, that sometimes coalesce to form a bed over a considerable area (1273/4). Internally the colour is red-grey—the iron being masked by carbonaceous matter. Veins of yellow calcite and chalybite form a central network.

The thickness is shown in the table at a minimum of 320 feet, measured in the borehole, and taking the sandstone found at the bottom as being the base of the group. At Wankie the figure is given as 750 feet (variable).

In the Bume River, three miles from Masosoni village, is a fissure in the clay filled with wax-like coal.

Another similar fissure among blue-grey clays contains a light red pisolitic ferruginous clay or botryoidal concretions, around centres of colloidal coal. Others are filled with iron, or both coal and iron.

VI.—Relationship of Karroo to Archæan Floor.

As in the areas already described by previous writers, the Karroo rocks lie as an overlap on the ancient floor. In regard to its eastern margin, the rocks of that floor will probably be found to belong to the Lomagundi system. There is no evidence that a fault forms the contact, though there is likely to be some structural line that favoured the direction of the Umniati river in its present course. How far the Karroo system may have extended eastward there is no evidence to say, but its curtailment, as seen to-day, has been brought about by the erosive action of the Umniati and its tributaries.

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ON THE VOLUMETRIC DETERMINATION OF PHOSPHORIC OXIDE.

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Read July 15, 1920.

In a previous communication* a process for the determination of phosphoric oxide was described which is claimed to be as accurate as other methods in common use, and in which the manipulation is simple and rapid. It was shown that when ammonium phospho-molybdate precipitated by the Lorenz sulphate-molybdate method† was dissolved in excess of sodium hydroxide, and the excess of alkali determined by titration with acid, the molecular ratio of sodium hydroxide to phosphoric oxide was 50 to 1. The present paper deals with the composition of the ammonium phospho-molybdate precipitate, and with some experiments on the applicability of the method.

COMPOSITION OF THE PRECIPITATE.

According to von Lorenz, the percentage of phosphoric oxide in his "Ammonium phosphormolybdat in seiner molybdänreichsten form" is 3·295. This result was obtained by starting with known quantities of phosphoric oxide and

* *S.A. Journ. of Science*, xv, 5, 357 (1918-19).
† *Landw. Versuchs Stationen*, lv, 183 (1901).

determining the weight of precipitate obtained—that is, by an indirect method. Working in the same way, we obtained $3·297 \pm 0·003$ for the percentage of phosphoric oxide. Since a knowledge of the composition of the precipitate would throw light on the volumetric process previously described, and possibly explain why the ratio of sodium hydroxide to phosphoric oxide was so much higher than ratios found for other modifications, the complete analysis of the precipitate was undertaken.

Method.—The scheme adopted for the analysis of the yellow precipitate was as follows: Precipitates were prepared and dried in partial vacuum after washing with acetone, as recommended by Neubauer and Lucker,* and were weighed. Some of these precipitates were dissolved in ammonia solution, the phosphoric acid precipitated as ammonium magnesium phosphate, the filtrate acidified with acetic acid, and the molybdic acid precipitated as lead molybdate. Considerable difficulty was experienced in effecting a satisfactory separation of the ammonium magnesium phosphate from molybdic acid. Two precipitations frequently failed to remove all molybdenum from the phosphate precipitate, and the separation is undoubtedly more difficult to effect quantitatively than when ammonium phospho-molybdate is precipitated by one or other of the modifications of the molybdate-magnesia method. For this reason, the sulphate-molybdate method of precipitation is not to be recommended for use when it is desired to weigh as magnesium pyrophosphate. Ammonia in the precipitate was determined by distillation into standard acid in the usual way, while water was estimated by drying in a current of air at 175 degrees.

The following data were obtained:—

AMMONIA.

	Ammonium phospho-molybdate taken.	$N/10\ H_2SO_4$ used.	NH_3 found.	NH_3
	gr.	c.c.	gr.	Per cent.
1.	0·7817	9·91	0·016881	2·16
2.	0·7844	10·09	0·017187	2·19
3.	0·7842	10·01	0·017051	2·17
4.	1·5053	19·38	0·033012	2·19

Mean: $2·18 \pm 0·003$.

* *Zeit. Anal. Chem.*, li. 161 (1912).

PHOSPHORIC OXIDE.

	Ammonium phospho-molybdate taken.	$Mg_2P_2O_7$ found.	P_2O_5 found.	P_2O_5
	gr.	gr.	gr.	Per cent.
1.	0·7802	0·0404	0·025772	3·303
2.	0·7848	0·0405	0·025836	3·292
3.	1·5041	0·0777	0·049567	3·295
4.	1·5129	0·0785	0·050078	3·310

Mean: 3·30 ± 0·004.

MOLYBDIC OXIDE.

	Ammonium phospho-molybdate taken.	$PbMoO_4$	MoO_3	MoO_3
	gr.	gr.	gr.	gr.
1.	0·7843	1·7435	0·68373	87·18
2.	0·7867	1·7479	0·68546	87·13
3.	1·5041	3·3359	1·30821	86·98
4.	1·5129	3·3539	1·31529	86·94

Mean: 87·06 ± 0·06.

WATER.

	Ammonium phospho-molybdate.	Weight after drying.	Loss.	Water.
	gr.	gr.	gr.	Per cent.
1.	1·5098	1·3966	0·1132	7·50
2.	1·5098	1·3952	0·1146	7·59

Mean: 7·54.

The figures given under (i) below are those found, while those given under (ii) are calculated for

$$11\ NH_3\ .\ 2\ P_2O_5\ .\ 52\ MoO_3\ .\ 36\ H_2O:—$$

	(i).	(ii).
NH_3 ...	2·18	2·18
P_2O_5 ...	3·30	3·30
MoO_3 ...	87·06	86·99
H_2O ...	7·54	7·53

We are therefore justified in assigning the above formula to the Lorenz ammonium phospho-molybdate precipitate.

This compound requires, according to the equation:

$$3\ (NH_4)_3PO_4\ .\ (NH_4)_2HPO_4\ .\ 52\ MoO_3 + 101\ NaOH + aq.$$
$$= 4\ (NH_4)_2HPO_4 + (NH_4)_2MoO_4 + NH_4NaMoO_4 + 50\ Na_2MoO_4 + aq.,$$

one hundred and one mols. of sodium hydroxide for two mols. of phosphoric oxide, *i.e.*, requires a ratio

$$NaOH : P_2O_5 = 50·5 : 1,$$

instead of 50 : 1, as found by experiment. We are at present unable to account satisfactorily for the discrepancy. The following experiments confirm the composition found. If by the addition of formaldehyde the ammonia be converted into hexamethylenetetramine, the amount of sodium hydroxide used to neutralise the precipitate with respect to phenolphthalein should correspond to the equation:

$$2\ P_2O_5\ .\ 52\ MoO_3 + 112\ NaOH$$
$$= 4\ Na_2HPO_4 + 52\ Na_2MoO_4 + 54\ H_2O.$$

Precipitates prepared from similar quantities of phosphoric oxide were dissolved in sodium hydroxide, with and without the addition of formaldehyde, and the excess of sodium hydroxide determined in the usual way, with the following results:—

(a). N/10 NaOH required for standard method.	(b). $(a) \times \frac{112}{101}$	N/10 NaOH required after adding CH_2O.
c.c.	c.c.	c.c.
36·60*	40·58	40·50
—	—	40·65

* Mean of several determinations.

If the phosphoric oxide as well as the ammonia be removed by suitable means from the alkaline solution to which excess of sodium hydroxide has been added, which was done by adding a solution of calcium chloride, the amount of alkali used should correspond with the equation:

$$2\ P_2O_5\ .\ 52\ MoO_3 + CaCl_2 + 116\ NaOH$$
$$= 2\ Ca_3(PO_4)_2 + 12\ NaCl + 52\ Na_2MoO_4.$$

The following results were obtained:—

(a) N/10 NaOH required for standard method.	(b) $(a) \times \frac{116}{101}$	N/10 NaOH required after adding CH_2O and $CaCl_2$.
c.c. 36·60*	c.c. 42·03	c.c. 42·05
—	—	42·05

It will be noticed, of course, that the values (b) given in the second columns of the two tables above are calculated on the basis of (a) being equivalent to 101, not 100, mols. of sodium hydroxide. The difference which would be made by taking the latter experimental figure instead of that indicated by the formula is, however, not great, and, in addition, the determination of the amounts of sodium hydroxide required is probably subject to the same errors in all three cases. Neither of the above modifications, the addition of formaldehyde or of calcium chloride or of both, is recommended, as the end point with phenolphthalein is not more sensitive than in the straightforward method.

To return to the difference between the amount of sodium hydroxide found necessary in practice and that required by the formula given to the precipitate, while we can at present offer no satisfactory explanation thereof, the variations found by other workers for modifications of the Pemberton alkalimetric process may be mentioned. Thus Pemberton† originally used a factor corresponding to the ratio

$$NaOH : P_2O_5 = 46·4 : 1;$$

later the same worker adopted the ratio 46 : 1, while recently Prescott‡ determined a factor corresponding to a ratio

$$NaOH : P_2O_5 = 47·2 : 1.$$

The second of these ratios corresponds to the formula for ammonium phospho-molybdate given by Hundeshagen,§ while

* Mean of several determinations.

† *Jour. Am. Chem. Soc.*, xv, 382 (1894).

‡ *Journ. Agr. Science*, vi, 111 (1914).

§ *Zeit. Anal. Chem.*, xxviii, 164 (1899).

the last corresponds roughly to the formula assigned to the yellow precipitate by Gibbs* and by Gladding.† There is abundant evidence to show that the reaction does not exactly follow theory when practically carried out. This is so well recognised that the U.S. Association of Official Agricultural Chemists no longer prescribes a conversion factor, but directs each chemist to determine his own. On the other hand, we have found no appreciable differences between results obtained by different chemists in this laboratory, where all use the same factor. The results given on this page serve as an illustration.

Influence of Silica and of Iron.‡

It is generally held that the previous removal of silica is essential to the success of the molydate-magnesia process for phosphoric acid. Silica is said not to interfere with the volumetric method used by the Association of Official Agricultural Chemists. But, if silica be precipitated as silico-molybdate along with the phospho-molybdate, it is difficult to see why it should not affect the alkalimetric method. Lorenz has shown that silica in amount up to 0·1 gram to 0·04 gram. of phosphoric oxide has no effect on his gravimetric process; consequently it should have no influence in the volumetric modification. A few results are given in support.

1. If basic slag be digested with sulphuric acid, practically no silica goes into solution; while if the extraction be made with nitric acid, very appreciable quantities of silica are dissolved. A sample of basic slag extracted by three different methods gave the following results:—

Method of Preparing Solution.	N/10 NaOH used for 0·1 gr.	P_2O_5 found.
	c.c.	Per cent.
1. Halle method§	66·75	18·96
2. Boiling sulphuric acid ...	66·70	18·94
3. Boiling sulphuric acid‖ ...	66·85	18·99
4. Boiling nitric acid‖ ...	66·85	18·99

* *Jour. Am. Chem. Soc.*, iii, 317 (1881).

† *Journ. Am. Chem. Soc.*, xviii, 23 (1896).

‡ The influence of citric acid and of ammonium citrate was discussed in the previous paper.

§ Wiley, H. W.: "Principles and Practice of Agricultural Analysis," vol. ii, p. 199 (2nd edition).

‖ Analyses by B. J. Smit, Assistant Chemist, Division of Chemistry.

2. Solutions of dicalcium phosphate in nitric acid were mixed with varying amounts of a solution of water glass, and also in most cases with varying quantities of ferric sulphate. The results, given below, show that dissolved silica and iron have no effect on the results, even when present in excessive amounts:—

	P_2O_5 taken.	SiO_2 taken.	Fe_2O_3 taken.	N/10 NaOH used.	P_2O_5 found.
	gr.	gr.	gr.	c.c.	gr.
1.	0·01040	—	—	36·60	0·01039
2.	0·01040	0·1983	—	36·60	0·01039
3.	0·01040	0·1322	0·0675	36·70	0·01042
4.	0·01040	0·0661	0·0675	36·65	0·01041
5.	0·01040	0·0661	0·1350	36·70	0·01042
6.	0·00208	0·0132	0·2700	37·35	0·00209

Influence of Amount of Phosphoric Oxide.

It is well known that the composition of the ammonium phospho-molybdate is liable to vary according to the nature of the solution in which precipitation takes place. For this reason the conditions of precipitation must be carefully controlled, in order that concordant results may be obtained by any method in which the precipitate is weighed or its amount determined volumetrically. In the process under discussion the concentration of molybdic acid is constant, the concentration of sulphuric acid and of ammonium sulphate is practically constant, and the concentration of nitric acid is also nearly the same in all cases. The variable factors are the concentration of phosphoric acid and of the other constituents of the substance under examination. The data given below show that for the useful range of a volumetric process the relation between phosphoric oxide and sodium hydroxide is constant—that is, that the composition of the precipitate is independent of the concentration of phosphoric acid in the solution in which precipitation takes place. Herein lies one of the greatest merits of the method. When once the solution containing the phosphoric oxide has been prepared—no matter how—no further treatment is necessary beyond the addition of the requisite amount of the sulphuric-nitric acid mixture (or of nitric acid alone) before proceeding with the precipitation. It is just this virtue which differentiates the Lorenz method of precipitation from others:—

	P_2O_5 taken.	N/10 NaOH used.	P_2O_5 corresponding to one c.c. of N/10 NaOH.
	gr.	c.c.	gr.
1.	0·00417	14·73	0·000283
2.	0·00625	22·10	0·000283
3.	0·00825	29·10	0·000284
4.	0·01032	36·30	0·000284
5.	0·01250	44·23	0·000283
6.	0·01459	51·60	0·000283
7.	0·02063	72·50	0·000285

The Determination of Small Amounts.

The process is particularly useful for determining very small quantities of phosphoric oxide. For this purpose it compares favourably with colorimetric processes, in that the phosphate solution may contain substances which interfere with the colour comparison, and the standard solution need not be adjusted to the composition of the solution to be tested. The full method may be carried out, or, if the volume of the phosphate solution be small, the volumes of the reagents may be reduced proportionately. In the latter case we have found that the precipitate is usually obtained in a finely divided state and is somewhat difficult to filter and wash. One-hundredth normal alkali and acid may be used; the end point is quite sharp. The following results were obtained on a solution of dicalcium phosphate in nitric acid; they illustrate the possibilities of the method when applied to the determination of small quantities:—

Regular Method: Final Volume 100 c.c.*

P_2O_5 taken.	N/10 NaOH.	N/10 H_2SO_4.	P_2O_5 found.
mgr.	c.c.	c.c.	mgr.
0·08	1·00	0·80	0·06
0·17	2·00	1·40	0·17
0·25	2·00	1·10	0·26

* Results by B. J. Smit, Assistant Chemist.

Regular Method: Final Volume 100 c.c.

P_2O_5 taken.	N/100 NaOH.	N/100 H_2SO_4.	P_2O_5 taken.
mgr.	c.c.	c.c.	mgr.
0·08	9·60	6·30	0·09
0·17	19·20	13·70	0·16
0·25	19·20	10·40	0·25

Modified Method for Small Volumes of Phosphate Solution.

Volume of phosphate solution.	Volume of sulphuric-nitric acid.	Volume of molybdate reagent.	P_2O_5 taken.	N/100 NaOH.	P_2O_5 found.
c.c.	c.c.	c.c.	mgr.	c.c.	mgr.
5	5	10	0·08	2·85	0·08
5	5	10	0·08	2·82	0·08
10	10	20	0·17	6·25	0·18
15	15	30	0·25	8·70	0·25

In conclusion, we wish to point out that von Lorenz, in his first paper already cited, reserved to himself the study of the composition of the precipitate obtained by his method in the following passage:—†

> "Die quantitative chemische Zusammensetzung des molybdänsäurereichsten, dabei schwefelsäurefreien Ammonium-Phosphormolybdates bietet zwar chemisches Interesse, ist aber, wie ersichtlich, für die praktische Ausführung der Phosphorsäurebestimmung belanglos. Ich behalte mir das Studium dieser Verbindung vor, halte es jedoch für höchst unwahrscheinlich, dass dafür eine halbwegs einfache Formel wird gefunden werden können."

We do not wish to be accused of poaching on other people's preserves, but the question was of some importance

* Results by B. J. Smit, Assistant Chemist.
† *Loc. cit.*, p. 214.

to the volumetric modification used in this laboratory, and eighteen years had passed since Lorenz wrote the above. We have been unable to find any reference to his having undertaken the analysis of the precipitate. Neubauer and Lucker in 1912 make no mention of any such work by Lorenz.

Finally, we desire to thank Mr. B. J. Smit, Assistant Chemist, Division of Chemistry, for the results quoted on pp. 264, 266 and 267.

SOME FURTHER FACTORS INFLUENCING THE SOLUBILITY OF PHOSPHORIC OXIDE IN MIXED FERTILISERS CONTAINING SUPERPHOSPHATES.

By Edmund Victor Flack,

Assistant Agricultural Chemist, Salisbury.

Read July 15, 1920.

The question of supplies of ingredients for compounding fertilisers during recent years has been a matter of serious consideration for those engaged in the trade, owing to shortage of materials imported from overseas. Since the publication of my previous article on "Some factors influencing the solubility of phosphoric oxide in mixed fertilisers containing superphosphate" (South African Journal of Science, xiii, 201-208, Dec., 1916) there were several mixtures other than those mentioned in the above paper which affect the solubility of phosphoric oxide.

In most of the mixed or complete fertilisers that have been recently placed on the South African market, material that was obtainable locally has had to be substituted in place of readily available forms of constituents. Especially was this the case as regards potash, as neither the sulphate, chloride nor nitrate has been available in quantity, and resort has been made to the large amount of available ash in the country. I refer more especially to the Union. It is a well-known fact that any material of a basic nature, such as calcium oxide, hydrate, or carbonate or ashes, should not be mixed on any account with water-soluble phosphoric oxide, owing to chemical action taking place, with a loss of water-soluble phosphoric oxide to that of water-insoluble forms. However, in view of the scarcity of suitable material, as previously mentioned, this has actually been carried out, and many of the mixed fertilisers, with few exceptions, have ashes either derived from kraal manure, seaweed or plant for supplying the necessary amount of potash.

To test how far the solubility is affected by other than those mentioned in the paper referred to above, the following mixtures were prepared: (a) Superphosphate and Ephos basic phosphate; (b) superphosphate and Saldanha Bay phosphate; (c) superphosphate and ground limestone; (d) superphosphate and kraal manure ash; (e) superphosphate and seaweed ash; (f) superphosphate and bush or plant ash.

The preparations of the above mixtures and analyses thereof were made on identical lines with those in my previous article.

The composition of the various materials used in this set of experiments was as follows:—

	Super-phosphate.	Ephos Basic Phosphate.	Saldanha Bay Phosphate.	Ground Limestone.	Kraal Manure Ash.	Seaweed Ash.	Plant Ash.
PHOSPHORIC OXIDE:							
Water soluble ...	19·70	*Nil*	*Nil*	*Nil*	—	—	—
2 per cent. Citric Acid	—	9·12	*Nil*	*Nil*	—	—	—
Total	21·70	29·52	21·15	trace	2·1	2·2	2·1
Lime	27·83	47·41	1·10	53·76	28·6	6·4	24·6
Potash	—	—	—	—	13·2	31·90	14·5

The following percentages of water-soluble phosphoric oxide were found in different mixtures:—

TABLE I.

	Original Composition.	Composition after standing 3 Hours.	24 Hours.	1 Week.	2 Weeks.	3 Weeks.
Superphosphate alone...	19·70	—	—	—	—	—
(a) Superphosphate and Ephos Basic Phosphate ...	9·85	9·10	8·94	8·61	8·12	7·93
(b) Superphosphate and Saldanha Bay Phosphate ...	9·85	9·34	9·37	9·21	8·91	8·77
(c) Superphosphate and Ground Limestone	9·85	1·32	0·43	0·30	0·29	0·18
(d) Superphosphate and Kraal Manure Ash	9·85	5·24	4·69	4·40	4·16	3·69
(e) Superphosphate and Seaweed Ash	9·85	6·01	5·44	5·42	5·12	4·69
(f) Superphosphate and Plant Ash ...	9·85	3·27	2·79	2·60	2·12	1·52

The following table shows the total percentage change in each of the mixtures during the specified periods:—

TABLE II.

	3 Hours.	24 Hours.	1 Week.	2 Weeks.	3 Weeks.
(a) Superphosphate and Ephos Basic Phosphate ...	−7·61	−9·24	−12·59	−17·56	−19·49
(b) Superphosphate and Saldanha Bay Phosphate ...	−5·18	4·88	−6·19	−9·24	−10·96
(c) Superphosphate and Ground Limestone	−86·61	−95·64	−96·95	−97·06	−98·17
(d) Superphosphate and Kraal Manure Ash	46·80	−52·38	−55·22	−57·77	−62·51
(e) Superphosphate and Seaweed Ash	−38·99	−11·77	−14·97	−18·02	−52·39
(f) Superphosphate and Plant Ash	−66·70	−71·67	−73·60	−78·48	−81·57

For comparison I append the results of other investigators on mixtures similar to those prepared by me, when equal parts of the respective materials have been employed:—

	Original Composition.	Immediately after Mixing.	19 Hours.	96 Hours.	14 Days.	35 Days.	76 Days.	117 Days.	208 Days.
Superphosphate (1) * and Basic Slag ...	5·95	2·28	1·26	1·22	1·30	1·20	1·16	1·20	1·12
Superphosphate (1) and Gafsa Phosphate ...	5·95	5·82	5·03	4·72	4·76	4·53	4·27	4·30	4·42

	Original Composition.	3 Hours.	24 Hours.	6 Days.	12 Days.	18 Days.
Superphosphate (2) * and Ground Limestone ...	8·87	7·87	1·75	1·12	0·75	1·25

	Original Composition.	Immediately after Mixing.	19 Days.	52 Days.	145 Days.
Superphosphate (3) * and Ground Limestone ...	6·77	2·40	0·99	1·10	0·87

* These and similar numbers refer to the list of References on p. 274.

In each of the following tables a minus sign shows reversion :—

	Immediately after Mixing.	19 Hours.	96 Hours.	14 Days.	35 Days.	76 Days.	117 Days.	208 Days.
Superphosphate (1) and Basic Slag ...	-61·68	-78·82	-79·49	-78·15	-79·83	-80·50	-79·83	-81·18
Superphosphate (1) and Gafsa Phosphate ...	-2·18	-15·46	-20·67	-20·00	-23·86	-28·23	-27·73	-25·71

	3 Hours.	24 Hours.	6 Days.	12 Days.	18 Days.
Superphosphate (2) and Ground Limestone ...	-11·27	-80·27	-87·37	-91·54	-85·90

	Immediately after Mixing.	19 Days.	52 Days.	145 Days.
Superphosphate (3) and Ground Limestone ...	-64·55	-85·37	-83·75	-87·15

The first three mixtures, namely, superphosphate with mineral phosphates and limestone, should be looked upon as more of a scientific nature, as such mixtures are not likely to find favour with farmers; yet, nevertheless, like mixtures have been recommended from time to time.

The result of a number of trials with a mixture of two parts of superphosphate (16 per cent. water-soluble phosphoric oxide) and one part of Tunisian phosphate are given in the January number of the "Journal of the Department of Agriculture and Technical Instruction for Ireland." This mixture, when applied at the rate of 3 to 6 cwt. per acre, had given favourable results with potatoes, mangolds, turnips and hay as compared with a similar dressing of superphosphate.

The Tunisian phosphate itself, according to the report, has given good returns, although slightly inferior to superphosphate; but the fact must be borne in mind that the residual value will be greater in the case of the untreated mineral phosphate than that of superphosphate. The same remark would apply when a mixture of superphosphate and mineral phosphate is applied. Professor Gilchrist, at Cockle Park, 1915, also reported favourably on a mixture of superphosphate and mineral phosphate over a three years' trial.

In the case of superphosphate and Ephos basic phosphate (treated phosphate by chemical fusion), the amount of reversion is gradual. At the end of three weeks it is under 20 per cent. When, however, attention is drawn to a mixture of a somewhat similar nature, namely, superphosphate and basic slag, the reversion takes place at a very rapid rate, and when calculated approximately to a period of little over three weeks there is a loss of water-soluble phosphoric oxide to the extent of about 79 per cent. The great difference between two such mixtures is probably due to the fact that basic slag contains a higher percentage of caustic lime than Ephos basic phosphate. Gray, in a set of experiments using slaked lime, found that the rate of reversion was particularly rapid, 94 per cent. of the water-soluble phosphoric oxide being reduced within three hours, and the whole amount present within twenty-four hours.

In a mixture of superphosphate and Saldanha Bay phosphate, which consists almost entirely of iron and alumina phosphate, with a trace of lime combined as carbonate, one would expect the loss in water-soluble phosphoric oxide to be great, yet the results prove that the rate of reversion is gradual, and at the end of a period of three weeks it is approximately only 11 per cent. In the case of superphosphate and Gafsa phosphate (a North African phosphate), although quoted by Robertson as probably being the most suitable for mixing with superphosphate, there is a reversion of about 22 per cent. when calculated on a period of little over three weeks.

It is evident from results of mixtures such as above there is no apparent gain to the farming community to

purchase such mixtures, more especially in Rhodesia, owing to the high ocean and railway freights.

The greatest loss of water-soluble phosphoric oxide, as was naturally to be expected, occurs in the limestone mixture. It can safely be said that chemical action starts immediately, and is continuous. After being mixed for three weeks the loss amounts to as much as 98 per cent., Gray's mixture at the end of eighteen days amounts to 86 per cent., and Brackett's after approximately five months to 87 per cent.

Burgest (4), State Agronomist of North Carolina, has recommended a mixture of 1,200 pounds of ground limestone to from 400 to 1,000 pounds of superphosphate.

The loss in reversion with mixtures of superphosphate and ashes vary greatly—from 52 to over 84 per cent. was obtained during a period of three weeks—the least reversion occurring with ash from sea plants, as against the highest with plant ash. This is due to the fact that the ash of sea plants contains less carbonates.

The mixtures with ashes should be of interest to merchants offering for sale compound or complete fertilisers when employed for making up the potash content.

The amount of reversion of water-soluble phosphoric oxide in mixtures such as above would vary considerably, due to the amount of lime in combination as oxide, hydrate or carbonate in the materials used for mixing purposes.

Conclusions.

Superphosphate should not be mixed with mineral phosphate, basic slag, Ephos basic phosphate, limestone or ashes, on account of reversion of water-soluble phosphoric oxide to that of water-insoluble phosphoric oxide being likely to take place at a very rapid rate in many instances.

A mixture could be made in the case of superphosphate and mineral phosphate if the amount of lime combined as carbonate is low in the untreated phosphate. The amount of reversion in such a mixture would probably be proportional to the amount of calcium carbonate present in the untreated rock phosphate.

REFERENCES.

1. Scott Robertson—
The rate of reversion of mixtures of superphosphate with basic slag and rock phosphates.—*Journ. of Sc. of Chem. Ind.*, vol. xxxvi, pp. 626-628.

2. Gray—
Transactions of the Australian Association for the Advancement of Science, Dunedin, January, 1904.

3. Brackett—
The action of calcium carbonate on acid phosphate.—E. W. Magruder, *Journ. of Ind. and Eng. Chem.*, vol. 9, p. 155.

4. Burgest—
Bulletin No. 220, North Carolina Dept. of Agric.

SOUTH AFRICAN FERN NOTES, WITH LIST OF FERNS AND FERN-ALLIES FOUND IN SOUTHERN RHODESIA, AND OF ADDITIONAL SPECIES RECORDED FOR OTHER SOUTH AFRICAN PHYTOGRAPHIC AREAS.

By T. R. Sim, D.Sc., F.L.S.

Read July 15, 1920.

It is only five years since the second edition of my "Ferns of South Africa" was published, but during these years the many specimens which have been sent to me demand considerable alteration in the geographical records of various species. Many additional locality records have been noted, which show that some of the species formerly considered rare have a fairly wide distribution, but I have not included these records in this paper, as they would unduly lengthen it. I show, however, what species are now recorded for the first time in each phytographical area, with localities for these, and indicate the total number of species now recorded for each of these areas.

As was to be expected, the older coastal areas, *i.e.*, West, East, Kaffraria and Natal, which were carefully worked years ago, provide very little additional, but the inland and northern areas continue to have increasing lists of species found, and probably will do so for years as localities become more accessible, since the fern flora is richer in species in the tropics, though confined there, as elsewhere, to suitable localities, leaving large dry areas almost destitute of ferns or fern allies.

Only one additional species is recorded for the whole of South Africa, *i.e.*, a small Selaginella, found in Basutoland by Madame Disterlin, closely resembling *S. depressa*, A. Br., in habit, size and appearance; this has been named at Kew *S. oxystachys* C. H. Wright, but I am not aware that it has yet been published.

The total number of Pteridophyta for South Africa up to the Zambesi is consequently 221 species.

In the various phytographic areas the following additional records and notes have been made:—

West:

Notholaena inaequalis, Kze. Kimberley (Bro. Moran).
Cyathea dregei, Kze. Knysna (T. H. Rex, 836).
Pellæa pteroides (Linn.), Pr. extends further inland than was previously known, as it has now been collected at Klipbank, Beaufort West Dist., by N. S. Pillans.
Pellæa lancifolia, Baker, formerly known only from Namaqualand, has now been found between Osplaat and Tunnel Siding, Worcester Division. (Rogers, 16751.)

Ninety-six species are recorded.

EAST:

There is no record of *Cyathea dregei*, Kze., as the Knysna locality formerly given is in West.

Eighty-nine species are now recorded.

KAFFRARIA:

No alteration; 109 species are recorded.

NATAL:

One hundred and fifty-one species are recorded.

Rehmann's 8184, issued as *Selaginella cooperi*, Baker, as received by me from Prince Bonaparte, is certainly *S. depressa*, A. Br., from which Baker's description of *S. cooperi* in "Fern Allies," page 68, does not distinguish it. Without seeing the type specimen it is inadvisable to sink *S. cooperi*, but I consider the name a synonym of *S. depressa*, A. Br.

BECHUANALAND:

Ceterach cordatum (Thby.), Desv.; Mochude (C. C. Harber).

Pellæa viridis (Forsk) Prantl. var. *glauca* Sim; Mochude (C. C. Harber).

Adiantum capillus-veneris, Linn.; Mochude (C. C. Harber; Rogers 6633).

ORANGE FREE STATE AND BASUTOLAND:

Junod collected between Mont aux Sources and Witzies Hoek, in January, 1917, several species as published by Prince Bonaparte in "Notes Pteridologiques," Fasc VII., October, 1918, page 325 onward, and Prof. Potts collected elsewhere in the State. There are now forty-one species and three varieties recorded, of which the following are not included in "Ferns of South Africa," 2nd ed.:—

Cystopteris fragilis (Linn.), Bernh.; Mont aux Sources (Junod, 17).

Dryopteris inaequalis (Schl.), O. Ktze. Mont aux Sources (Junod, 13).

Dryopteris inaequalis (Schl.), O. Ktze.; Mont aux Sources (Junod, 18).

Asplenium Kraussii, Moore; Mont aux Sources (Junod, 10).

" *trichomanes* (Linn.); Mont aux Sources (Junod, 6).

" *praemorsum*, Sw.; Leeuwberg, Bloemfontein (Potts), Mont aux Sources (Junod, 5).

" *praemorsum*, Sw., *var. tripinnatum*, Modderpoort (Rogers, 91).

Blechnum tabulare (Thbg.), Kuhn; Mont aux Sources (Junod, 10).

Selaginella rupestris, Spr.; Fauriesberg, 6,200 feet (Potts, 1954).

Asplenium praemorsum, Sw., var. *angusti-tripinnatum*, Bonap. "Notes Pterid," VII., 328, from Mont aux Sources (Junod, 3), is only a rather dried and withered condition of *A. praemorsum*, Sw. var. *tripinnatum*, Sim.

TRANSVAAL:

Many fresh localities have been noted, mostly from collections made by Prof. Moss, Prof. Wager, Ven. Archdeacon Rogers, Mrs. Pott and Mr. Cunliff. There are now 124 species known, including the following not previously recorded:—

Hymenophyllum lineare, Sw.; Kaapsche Hoop (Wager). Confirms previous doubtful record.

,, *marlothii*, Brausse; Kaapsche Hoop (Wager).

,, *tunbridgense*, Sm.; Kaapsche Hoop (Wager).

Cystopteris fragilis (Linn.), Bernh.; Mavieriestad, Ermelo (Mrs. Pott).

Asplenium platyneuron (Linn.), Oakes; Mavieriestad, Ermelo (Mrs. Pott).

,, *cuneatum*, Lam., var. *angustatum*: The Downs, Pietersburg (Moss and Rogers, 312).

Cheilanthes depauperata, Baker; Johannesburg (Rogers and Moss).

Adiantum poiretii, Wilkst.; The Downs, Pietersburg (Rogers, 20139).

Elaphoglossum conforme (Sw.), Schott, var. *latifolium*, Sim; Kaapsche Hoop (Wager).

Schizæa pectinata (Linn.), Sw.; Messina (Moss and Rogers, 1415).

Lycopodium saururus (Lam.); Kaapsche Hoop (Wager).

PORTUGUESE EAST AFRICA:

Portuguese East Africa has now forty-eight species known, including the following, which were not recorded in "Ferns of South Africa," 2nd ed., but were mostly collected by Junod, and published by Prince Bonaparte in "Notes Pteridologiques, VII., October, 1918, pages 323 onward:—

Cyathea dregei, Kze.; Moramballa (Waller, Livingstone, Kirk).

Nephrolepis biserrata (Sw.), Schott; Lourenço Marques (Junod).

Asplenium bipinnatum (Forst.), C. Chr.; Lourenco Marques (Junod).

Davallia chaerophylloides (Poir), Steud.; Lourenço Marques (Junod).

Polypodium lycopodioides, Linn.; Lourenco Marques (Junod).

,, ,, var. *Mackenii*, Sim; Lourenço Marques (Junod).

Concerning *Stenochlaena tenuifolia* (Desv.), Moore, Prince Bonaparte points out that occasional fronds are sterile at the base, but the upper pinnae are fertile, as seen in specimens from Junod from Lourenço Marques ("Notes Pteridologiques," Fasc. VII., 320, and IV., 52).

SOUTHERN RHODESIA:

Soon after my "Ferns of South Africa," 2nd edition, was published in 1915, Mr. F. Eyles' very valuable "Record of Plants Collected in Southern Rhodesia," was published in the "Trans-

actions of the Royal Society of South Africa," vol. v., part 4, May, 1916, in which is included 126 species and thirteen varieties of Pteridophyta, from which, however, a few have to be altered as follows:—

Davallia concinna, Schrad., and *D. theeifera*, H.B.K., are synonymous, and are now included in *Asplenium theciferum*, H B.K.

Ancimia tomentosa, Sw.; Teague's No. 69 cited belongs to *A. anthriscifolia*, Schrad., and there is no other record of *A. tomentosa* for S. Rhodesia.

Aspidium ammifolium, Poir, is the South African form of *Polystichum aculeatum* (Linn.), Schott, and represents that species in Eyles' list.

Cyathea manniana, Hook, and *C. thomsoni*, Baker, may be good species, and may be present, but Swynnerton's 6030 and 817, as sent to me by him, are both *C. dregei*, Kunze.

Polypodium obtusilobum, Desv., is a condition of *Dryopteris bergiana*, O. Ktze.

This reduces Eyles' list to 121 species and 13 varieties.

In "Ferns of South Africa," 1st edition (1892), 24 species were mentioned as Rhodesian; in the 2nd edition (1915) 126 species, and now I have records of 140 species besides 20 varieties, a few of which, however, have rather indefinite locality records, such as "Zambesi highlands" or "Zambesia."

Eyles' list followed the nomenclature of my first edition, which was based on Baker's "Synopsis Filicum." Unfortunately the researches of C. Christenson, O. Kuntze, Prince Bonaparte and others had so completely revolutionised the generic nomenclature that wholesale readjustment became necessary in my second edition, which follows Christenson's "Index Filicum" (1906) and supplement (1913)—the nomenclature now in general use—and this results in about half of the names used in Eyles' list being discarded, and now regarded as synonyms. In view of this, I have prepared a complete list of the Pteridophyta of S. Rhodesia, using present nomenclature, and showing synonymy as used in my first edition or in Eyles' list. The localities mentioned in these have not been repeated, nor additional localities given for these species, but localities are given for all additional species.

It may be necessary to further investigate *Asplenium hollandii*, Sim, which corresponds exactly with specimens from Kilimandjaro sent by Prince Bonaparte to me, named *Asplenium hypomelas*, Kuhn. Kuhn ("Filices Africanae," page 104, 1868) gives no description, but cities as synonyms "*Davallia nigrescens*, Hk. ic. f. Cent. II., tab. 93—*Loxoscaphe nigrescens*, Moore, Index, 297," from Fernando Po (Mann 448, in distr. hb. Kew, 253. C. Christenson maintains the species as *A. hypomelas*, Kuhn, and with the above synonyms, as from Fernando Po only. If the species belongs to continental Africa as well as to Fernando Po, my name may be a synonym, or the fern may be specifically distinct; this has to be investigated.

Further investigation is also required as to the relationship of *Asplenium eylesii*, Sim; *A. pumilum*, Sw.; and *A. marlothii*, Hieron, a group not yet sufficiently well known.

Concerning *Dryopteris patens*, O. Kuntze, C. Christensen, in "A Monograph of the Genus Dryapteris," Part I., 1913, page 177, writes: "Specimens from Africa and Polynesia are often determined *D. patens;* this species is, however, no doubt confined to America; the Polynesian plant is partly *D. Harveyi* (Mett) and partly *D. Brackenridgei* (Mett); the African *D. Bergiana* (Mett), and *D. Gueintziana* (Mett)."

Concerning *Elaphaglossum lineare* (Fée), Moore, I may mention that through a slip it is wrongly described in the synopsis in "Ferns of South Africa," page 285, as having fronds two inches wide; this should be $\frac{1}{4}$in. to $\frac{1}{3}$in. wide.

Collections of ferns received from Kilimandjaro and Mount Meru, and from the bamboo zone of Mount Elgon, Uganda (7,000 ft. to 9,000 ft.), demonstrate that most of the common ferns there are also Rhodesian, and that probably 90 per cent. of all species of Pteridophyta found there occur in South Africa also.

LIST OF PTERIDOPHYTA OF SOUTHERN RHODESIA.

ORDER I, FILICES.

(1) Hymenophyllaceae:

Trichomanes pyxidiferum, Linn. (=*T. bipunctatum*, Poir of C. Chr. "Index Filicum," and of Prince Bonaparte's "Notes Pteridologiques," VIII., p. 51; Umtali (L. Cripps); (F. Eyles, 1710).

Hymenophyllum inaequale (Poir), Desv. (=*H. gracile*, Bory).

,, *ciliatum*, Sw., Zambesi district (Syn. Fil.).

(2) Cyatheaceae:

Cyathea dregei, Kunze; the specimens cited as *C. manniana*, Hk., and *C. thomsoni*, Hk., by Eyles, belong to *C. dregei*, Kunze.

(3) Polypodiaceae:

Cystopteris fragilis (Linn.), Bernh.

Dryopteris orientalis (Gmel.), C. Chr. (=*Nephrodium albo-punctatum*, Desv.).

,, *bergiana* (Sehl.), O. Ktze (=*N. bergianum*, Baker, and includes *Polypodium obtuselobum*, Desv.).

,, (*patens* (Sw.), O. Ktze, should be excluded; see remarks above.)

,, *mauritiana* (Fée), C. Chr. (=*Neph. mauritiana*, Fée).

,, *mollis* (Jacq.), Hieron (=*Neph. molle*, Desv.)

,, ,, var. *violascens* (Link.), Mett.

,, *gongylodes* (Schk.), O. Ktze. (=*Neph. unitum*, R.Br.).

(3) POLYPODIACEAE (*contd.*):

Dryopteris prolifera (Retz.), C. Chr. (= *Polypodium proliferum*, Pr.).
,, *silvatica* (P. & R.), C. Ch. (=*Polypodium unitum*, Hk.).
,, *thelypteris* (Linn.), R. Gr. (=*Neph. thelypteris*, Desv.).
,, *zambesiaca* (Baker), C. Chr.; Zambesi highlands (Buchanan).
,, *elongata* (Sw.), Sim (=*Neph. filix-mas*, Rich., var. *elongatum*, Hk.).
,, *inaequalis* (Schl.), O. Ktze. (= *Neph. inaequale*, Hook).
,, *athamantica* (Kze.), O. Ktze. (= *Neph. athamanticum*, Hook).
,, *buchanani* (Baker), O. Ktze. (= *Neph. buchanani*, Baker).
,, *lanuginosa* (Willd.), C. Chr. (= *Neph. catopteron*, Hook).
Didymochlaena truncatula (Sw.), I. Sm. (= *D. lunulata*, Desv.).
Aspidium cicutarium (Linn.), Sw. (=*Neph. cicutarium*, Baker).
Polystichum aculeatum (Linn.), Schl. (= *Aspidium aculeatum*, Sw.), includes *Aspidium ammifolium*, Poir.
,, *pungens* (Klf.), Pr. (=*Aspidium aculeatum*, Sw., var. *pungens*).
,, *adiantiforme* (Forst.), I. Sm. (= *Aspidium capense*, Willd.); Makoni dist. (Eyles, 918).
,, *aristatum* (Forst.), Pr. (=*Aspidium aristatum*, S.W.).
Leptochilus auriculatus (Lam.), C. Chr.; Zambesiland (Syn. Fil.).
Nephrolepis biserrata (Sw.), Schott, Zambesiland.
,, *exaltata* (Linn.), Schott.
,, *cordifolia* (Linn.), Presl.
Microlepia speluncae (Linn.), Moore (= *Davallia speluncae*, Baker).
Athyrium filix-faemina (Linn.), Roth (= *Asplenium filix-foemina*, Bernh.).
,, *schimperi*, Moug., Salisbury (Darling; *teste* Eyles' list).
,, *scandicinum* (Willd.), Presl. (= *Asplenium aspidioides*, Schl.).
Asplenium kraussii, More; Umsusa veld, by water, 3,500 ft. (L. Cripps).
,, *sandersoni*, Hook.
,, *trichomanes*, Linn.
,, *monanthes*, Linn. (= *A. monanthemum*, Linn.).

(3) Polypodiaceae (*contd.*):

Asplenium lunulatum, Sw. (=*A. erectum*, Bory).
var. *lunulatum*, Sw.
var. *erectum* (Bory), Sim.
var. *gracile* (P. & R.), Sim (=var. *lobatum*, Sim).
,, *varians*, Wall.
,, *eylesii*, Sim.
,, *pumilum*, Sw.
,, *protensum*, Schrad.
,, ,, var. *bipinnatifidum*, Sim; Victoria Falls (Jas. Sim).
,, *laetum*, Sw.
,, *anisophyllum*, Kze.
,, *unilaterale*, Lam. (=*A. resectum*, Sm.).
,, *serra*, Langs. & Fisch.
,, *adiantoides* (Linn.), C. Chr.
,, *gemmiferum*, Schr.
,, ,, var. *flexuosum*, Schr.
,, *adiantum-nigrum*, Linn.
,, *cuneatum*, Lam.; Umtali (F. Eyles, 1687).
,, ,, var. *angustatum*, Sim; Umtali (L. Cripps).
,, *praemorsum*, Sw (=*A. furcatum*, Thunb.).
,, ,, var. *rupestre*, Sim, M.S.; Makoni (F. Eyles, 745).
,, ,, var. *tripinnatum*, Sim.
,, *abyssinicum*, Fée; (*A. cicutarium*, Sw. =*A. cristatum*, Lam.).
,, *dregeanum*, Kze.
,, *auriculatum* (Thbg.), Kuhn (=*A. thunbergii*, Kze.).
,, *bipinnatum* (Forsk.), C. Chr. (=*A. rutaefolium*, Kze.).
,, *theciferum*, H.B.K. (=*Davallia concinna*, Schr.).
,, *hollandii*, Sim (=*Davallia hollandii*, Sim).
,, *mannii*, Hk.

Ceterach cordatum (Thbg.), Desv. (=*Gymnogramma cordata*, Sch.).
,, ,, var. *namaquensis*, P. & R.

Blechnum attenuatum (Sw.), Mett. (=*Lomaria attenuata*, Willd.).
,, *punctulatum*, Sw. (=*Lomaria punctulata*, Kze.).
,, *capense* (Linn.), Schl. (=*Lamaria procera*, Spr.).
,, *tabulare* (Thbg.), Kuhn (=*Lomaria boryana*, Willd.).

Anogramma leptophylla (Linn.), Link. (=*Gymnogramma leptophylla*, Desv.).

Gymnogramma argentea (Willd.), Mett.
,, *aurea*, Desv. (=*G. argentea*, Mett., var. *aurea*).

(3) POLYPODIACEAE (*contd.*):

Pellæa dura (Willd.), Baker (=*P. burkeana*, Baker).
,, *goudotii* (Kze.), C. Chr. (=*P. pectiniformis*, Baker).
,, ,, var. *major*, Sim.
,, *quadripinnata* (Forsk.), Prantl. (=*P. consobrina*, Hook).
,, *viridis* (Forsk.), Prantl. (=*P. hasta*, Link).
,, ,, var. *Macrophylla*, Sim.
,, ,, var. *glauca*, Sim.
,, *doniana* (I. Sm.), Hook.
,, *hastata* (Thbg.), Prantl. (=*P. calomelanos*, Ling).
,, *swynnertoniana*, Sim.
Doryopteris concolor (L. & F.), Kuhn (=*Pellæa geranii-folia* Fée).
Notholaena inaequalis, Kze.
,, *buchanani*, Baker.
,, *eckloniana*, Kze., Victoria (C. F. H. Monro, 1055).
,, *bipinnata*, Sim.
Cheilanthes hirta, Sw.
,, ,, var *contracta*, Kze.; Makoni dist. (Eyles, 728).
,, *multifida*, Sw.
,, *bolusii*, Baker.
,, *farinosa* (Forsk.), Klf.
Hypolepis sparsisora (Schrad.) Kuhn (=*H. anthrisci-folia*, Pr.).
,, *bergiana* (Schl.), Hk.
,, *schimperi* (Kze.), Hk.
Adiantum caudatum, Linn.
,, *lunulatum*, Burm.
,, *oatesii*, Baker.
,, *hispidulum*, Sw.
,, *capillus-veneris*, Linn.
,, ,, ,, var. *major*, Sim.
,, ,, ,, var. *laciniata*.
,, *aethiopicum*, Linn.
Actiniopteris australis (Linn. fil.), Link. (=*A. radiata*, Link.).
Pteris longifolia, Linn.
,, *cretica*, Linn.
,, *dentata*, Forsk. (=*P. flabellata*, Thunb.).
,, *biaurita*, Linn. (=*P. quadriaurita*, Retz.).
,, *brevisora*, Baker.
,, *atrovirens*, Willd.
Pteridium aquilinum (Linn.), Kuhn (*Pteris aquilina*, Linn.).
Vittaria isoetifolia, Bory (=*V. lineata*, Sw.).
Polypodium parvulum, Bory.
,, *polypodioides* (Linn.), Hit. (=*P. incanum*, Sw.).
,, *phymatodes*, Linn.

(3) Polypodiaceae (*contd.*):

Polypodium lineare, Thunb., Umtali (Cripps); Inyanga (Dr. Nobbs).
,, ,, var. *schraderi* (Mett), Sim; Umtali, (L. Cripps).
,, *pappei*, Mett. (= *P. normale*, Don, of Eyles' list).
,, *lanceolatum*, Linn.
,, *loxogramme*, Mett. (= *Gymnogramma lanceolata*, Hook).
,, *punctatum* (Linn.), Sw. (= *P. irioides*, Lam.).
Cyclophorus africanus (Kze.), C. Chr. (= *Polypodium africanum*, Mett.).
Elaphoglossum conforme (Sw.), Schott., var. *latifolium*, Sim (=*Acrostichum conforme*, Sw. var.
,, *petiolatum* (Sw.), Urban (= *Acrostichum viscosum*, Sw.).
,, *aubertii*, Desv. (=*Acrostichum aubertii*, Desv.).
,, *lineare* (Fée), Moore (=*Acrostichum lineare*, Fée).
Platycerium bifurcatum (Cav.), C. Chr. (= *P. alcicorne*, Gaud.).
,, *umbraculifera* (Kze.), Moore.

(4) Gleicheniaceae:

Gleichenia polypodioides (Linn.), Smith.
,, *umbraculifera* (Kze.), Moore.
,, *linearis* (Burm.), Clarke (= *G. dichotoma*, Kunze).

(5) Schizæaceae:

Lygodium kerstenii, Kuhn (= *L. subalatum*, Bojer).
,, *brycei*, *Baker*.
Mohria caffrorum, Desv.
, *lepigera*, Baker.
Anemia anthriscifolia, Schrad. Many eastern localities.

(6) Osmundaceae:

Todea barbara (Linn.), Moore (=*T. africana*, Willd.).
Osmunda regalis, Linn.

ORDER II, MARSILIACEAE.

Marsilia macropoda, Presl.; Bulawayo (F. Eyles, 1301).
,, ,, var. *biloba* (Willd.), Sim; Gwelo (Gardner 28, *teste* Eyles).
,, ,, var. *capensis* (A. Br.), Sim.
,, ,, var. *lobata*, Sim.

ORDER III, MARATTIACEAE.

Marattia fraxinea, Sim.

ORDER IV, OPHIOGLOSSACEAE.

Ophioglossum capense, Sw. (= *O. vulgatum*, Linn.).
,, *reticulatum*, Linn.

ORDER V, LYCOPODIACEAE.

Lycopodium verticillatum, Linn.
,, *dacrydioides*, Baker: Zambesiland, etc. (Syn. Fil.).
,, *cernuum*, Linn.
,, *clavatum*, Linn. (= *clavatum*, Linn., var. *inflexum*, Spr.).

ORDER VI, SELAGINELLACEAE.

Selaginella rupestris, Spr.
,, *depressa*, A. Br.
,, *kraussiana*, A. Br.
,, *imbricata*, Spr.
,, *molliceps*, Spr.

ORDER VII, PSILOTACEAE.

Psilotum triquetrum, Sw.

ORDER VIII, EQUISETACEAE.

Equisetum ramosissimum, Desv.

THE LEAVES OF *HAKEA PECTINATA* AND *H. SUAVEOLENS*.

By Horace A. Wager, A.R.C.Sc.,
Professor of Botany, Transvaal University College, Pretoria.

With Two Text Figures.

Read July 15, 1920.

Hakea pectinata has a much-divided compound leaf, the segments being cylindrical and sharply pointed. The leaf shows strong xerophytic characters. A cylindrical segment has the same structure all round. As seen in transverse section, there is a central vascular tissue, consisting of one large and several smaller bundles lying in soft ground tissue, with small patches of sclerenchyma generally connected with the bundles. This central tissue is separated from the assimilative tissue—mostly palisade cells—by a definite ring of cells. Then there is a well-defined epidermis with thick cuticle and sunken stomata. The most striking feature in the structure of the leaf, however, is the presence of peculiar thickened, elongated, single cells, termed idioblasts. These are very numerous, and run radially through

the assimilative tissue, and have root-like extensions at right angles at both ends. Each idioblast cell rests by means of these extensions against the epidermis on one side and against the central cylinder on the other (Fig. 1). Obviously these cells are

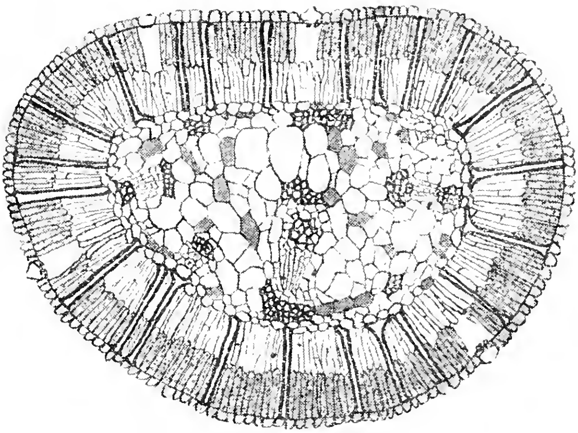


Fig. 1.—Transverse Section of Leaf of *Hakea pectinata*.

mechanical in function, and by their means the shape and rigidity of the cylindrical segments are maintained. Especially do they prevent collapse of the tissues. This leaf has probably evolved on xerophytic lines from a flat, more expanded and delicate type. These idioblast cells do not constitute a xerophytic character in themselves, but by their means the leaf was enabled to assume, as it were, the cylindrical form.

In the case of *Hakea suaveolens*, a common hedge plant of the Transvaal, the leaf is simple, thin, flattened, rather narrow and bifacial. It still, however, shows xerophytic characters, such as toughness, thick cuticle and sunken stomata. In section, similar idioblast cells are found to be present in large numbers, of exactly the same type as those found in *H. pectinata*. Each

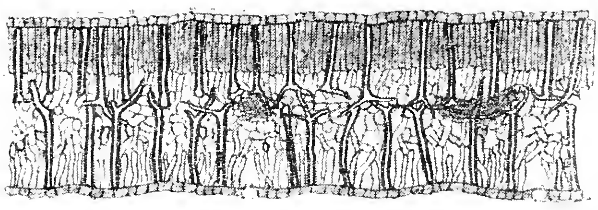


Fig. 2.—Transverse Section of Leaf of *Hakea suaveolens*.

extends, however, in this case from either the upper or lower epidermis to the middle of the leaf, where the extensions at the extremities either intermingle or rest against some of the mesophyll cells. None of them passes across the leaf from one epidermis to the other (Fig. 2). The use of such idioblast cells

in a leaf of this type is not very apparent. They certainly cannot be required to carry out the same function as in *H. pectinata*. It is, I think, understandable that such a type of idioblast cell should arise in the evolution of the xerophytic type of leaf with cylindrical segments from some flat xerophytic or non-xerophytic form. If *H. pectinata* was evolved from the *H. suaveolens* type, it would become necessary to explain the need for and presence of the idioblast cells in *H. suaveolens* as being the first type in which they appeared. I think, however, that we have here a case of reversion, that is, that the type of leaf as found in *H. suaveolens* has been evolved from that of *H. pectinata*. We have to imagine that *H. pectinata* has endeavoured to return to a normal type of flattened leaf whilst still retaining its xerophytic characters. In so doing the idioblast cells have been retained simply as an atavistic feature, and no longer function in any mechanical way. Evidence of evolutionary reversion is very rare amongst plants. At present I have been unable to examine the leaves of any other hakeas, so perhaps this short account is incomplete. As a preliminary note, however, it may be of value in showing that more evolutionary connections amongst plants may be looked for.

NOTE ON THE I-KOWE OR NATAL KAFIR MUSHROOM, *SCHULZERIA UMKOWAAN*.

By PAUL A. VAN DER BIJL, M.A., D.Sc., F.L.S.,
Natal Herbarium, Durban.

Read July 15, 1920.

The Kafirs are especially careful in selecting mushrooms for eating, and mushroom poisoning among them is seldom heard of.

They avoid several edible mushrooms, such as *Coprinus comatus* (the shaggy inky cap), *Letiopa procera* (the parasol mushroom) and others; and they are even very sceptical about the common European mushroom—*Agaicus campestris*. They, however, relish their "i-Kowe"—a large mushroom popularly known to Europeans as the beefsteak or butter mushroom—and during the season it is not uncommon to see natives return from the fields for breakfast with freshly collected "i-Kowe" in their hands.

This mushroom was first named by Cooke and Massee in 1889 from specimens sent by the late Dr. Medley-Wood. For the specific name they selected *Schulzeria umkowaan*, which they were evidently informed was the native name.

As far as I can find out the natives invariably know this mushroom under the name "i-Kowe," and specimens which they call "in-Kowaan" are referable to *Agaricus campestris* and the closely allied *A. placomyces*.

The term "*in-Kowaan*" correctly translated means "little *i-Kowe*," as also the native name "*in-Kowankowahe*." A mushroom given me under the latter name was *A. campestris*.

The native names for mushrooms appear to refer to size rather than anything else. The name "*i-Kowendhlovu*" means the very large or elephant "i-Kowe," but I have not had such a mushroom handed to me. May be it is used in referring to an especially large specimen of *Schulzeria um-kowaan* or is another name used for this mushroom in certain parts of the country.

I am told that "Kowe" means something spongy, and that it is probably derived from the native word for "spongy" or "springy." The "i-Kowe" now frequently finds a place on the tables of Europeans and either fried in butter or stewed is much appreciated and considered quite a delicacy.

The most remarkable part about this mushroom is probably its deeply rooted stalk, the underground portion of which is 25 cms. or more long, and usually thickens from its insertion downwards to the ground level, and from here thins off again to the apex. Its entire dimensions are 25 to 40 cms. long by 1·5 to 5 cms in diameter, and usually it is more or less curved. It is solid within and tough.

The cap is distinct from the stalk, circular, bell shaped in young specimens, and very young specimens have a pronounced club-shaped appearance. In diameter the cap usually varies from 10 to 24 cms., and is white to tan coloured, dull and smooth. An umbo is present above the insertion of the stalk. The cap frequently splits and the margin then turns upwards.

The gills are free from the stalk, white and up to 5 mm. broad. The spores are hyaline under the microscope, grey in spore print, elliptical, usually obliquely apiculate, and measure 3·7 μ to 5 μ by 7.5 μ to 10 μ; the majority are about 8 μ to 9 μ long. In the original description there is no mention of the apiculum to the spores.

Radicating and deeply rooted stalks, such as are found in *Schulzeria umkowaan*, are on the whole not common in the gill fungi, though several species of the genus *Collybia* have such stalks.

A PAW-PAW LEAF-SPOT CAUSED BY A *PHYLLOSTICTA* SP.

By Paul A. van der Bijl, M.A., D.Sc., F.L.S.,
Natal Herbarium, Durban.

Read July 15, 1920.

A leaf spot disease does not appear to have been generally reported on the paw-paw from the Union of South Africa, though it is not uncommon in Natal.

The fungus responsible is a species of *Phyllosticta.*

The discoloured spots measure on an average 2 mm. to 5 mm. across, and may be circular or angular, or more or less elongated in one direction. They are frequently circumscribed by a yellow or brownish ring, which passes into the normal green of the leaf. Individual spots frequently coalesce. On the upper leaf surface small black dots are evident in these discoloured areas, and they are the pycnidia of the causal fungus.

The leaf tissues in the infected areas become brittle, and ultimately fall out, giving the leaves a "shot-hole" appearance.

The fungus was isolated by ordinary methods from leaves obtained in plantations, and from subcultures of this paw-paw leaves were artificially inoculated as follows:—

Experiment I.—A small plant was taken and areas marked with a pencil on the lower surfaces of three of the leaves. Pieces of the mycelium from a pure culture were placed on these areas. The under surfaces of the leaves were then syringed with distilled water, and the whole plant covered with a bell jar to preserve a moist atmosphere.

The results were as follows:—

The first leaf had eight areas inoculated, of which six became infected after six days. The second leaf had eight areas inoculated, of which six showed infection after six days. The third leaf had seven areas inoculated, of which six were infected after six days.

The infected spots were circular, greyish or dark brown, 2 mm. to 7 mm. diameter, and decidedly brittle. Pycnidia were evident within twenty days in the discoloured areas on the upper leaf surface.

Experiment II. was carried out in the same way, three marked areas being inoculated. Two of these became infected after five days, and pycnidia developed within twelve days.

It should be noted that the period of six days stated for the development of pycnidia must not necessarily be taken as the minimum period, as the plants could not always be examined regularly.

The mycelium measured 2·8 μ to 3·8 μ across, and appears primarily intercellular. Evidently some enzyme which kills the cells of the host is excreted by the fungus. The cells in the region of the discoloured areas are much shrivelled up and collapsed, and in section these areas appear thinner than the rest of the leaf.

As mentioned, the pycnidia are evident in the white areas on the upper leaf surface as minute black dots.

These pycnidia are at first sub-epidermal, and later become erumpent. They measure 80 μ to 106 μ in diameter; have thin walls, are globose in shape and contain numerous spores of the fungus.

The spores are hyaline, straight to slightly curved, rounded at both ends, and measure 4·4 μ to 5·8 μ by 1·5 μ to 1·8 μ.

Their walls do not colour with Schulze's solution, but the contents turn reddish brown when treated with iodine. Evidently the contents consist largely of glycogen.

The fungus grows well in culture media, though pycnidia do not appear to be readily formed. In beerwort agar plates a woolly, white to greyish growth developed within six days. Reverse of petri-dish was coloured grey, and changed to a dark brown. Aerial hyphae measured 3·7 μ to 7·4 μ. Pycnidia were observed after twelve days, and more abundantly along the sides of the petri-dish, 66·5 μ to 133 μ in diameter, one to two ostiolate. Spores hyaline, with rounded ends 3·7 μ to 5·5 μ by 1·9 μ.

On oatmeal agar slants a woolly, white to greyish growth occurred, which, where medium, glass and growth meet, is dark neutral in colour. Directly on medium dense felt-like mass of interwoven hyphae, dark in colour, occur. Pycnidia were not found.

On sterilised rice in tubes, a white woolly growth occurred, which, where rice, growth and glass meet, is reddish brown to dark neutral. Immediately around individual kernels, growth was densely matted and interwoven and brown in colour. Here the septa are close together and the indivdual cells become swollen. Hyphae 3·7 μ diameter or thicker in swollen mass around kernels.

On artificial media the hyphae were usually rich in oil globules.

A paw-paw was inoculated by inserting small pieces of the mycelium from pure culture into punctures made in marked areas on a paw-paw. On the same paw-paw similar areas were marked and punctured but not inoculated. These latter served as controls. After inoculation the paw-paw was covered with a bell jar and left at room temperature. Five days after inoculation some of the infected areas showed reddish brown depressions, and were soft to the touch. Pycnidia had by this time formed in one of the inoculated spots. The control punctures were normal.

As in the leaf the pycnidia are here originally subepidermal. They measure 66 μ to 120 μ in diameter, and are separate or a few aggregated together

The economic importance of the fungus, responsible for leaf-spot or "shot-hole," is that in attacked leaves the assimilating

area is diminished. The infection of a paw-paw through a puncture would, however, indicate that this fungus may also play some part as a causal agent of a fruit-rot of the paw-paw.

Three fungi have been described as causing leaf-spots in the paw-paw; viz., *Phoma microsporella*, Karst & Har.; *Phyllosticta Papayae*, Sacc. and *Phyllosticta Caricae-Papayae*, Allesch. The fungus dealt with in this paper is referred to *Phyllosticta Caricae-Papayae*, Allesch., the description of which reads: "Maculae subochraceo-pallidae; perithecia minutissima, nigra; sporulae 3 μ to 4 μ x 1 μ, hyalina. Hab. in foliis vivis Carica Papayae in Brasilia."

AN EXHIBIT OF STONE IMPLEMENTS FROM TIGER KLOOF AND TAUNGS, CAPE COLONY.

By Rev. Neville Jones, F.E.S.

Read July 15, 1920.

The collection of stone implements, which was exhibited, was obtained from Tiger Kloof and Taungs in the northern part of the Cape Province. The position of the Tiger Kloof deposit was described, and it was considered to be the remnants of a very old river terrace, and its implements were essentially similar to those of the Chellean Age in Europe. Old Bushman implements occurred in the overlying deposit, but no hand-axes, such as came from the gravel beneath, had been found.

With regard to the Taungs deposit, its occurrence in the valley, where the present river flows, suggests that it is of more recent date than that of Tiger Kloof. From consideration of a number of implements similar to those of the Acheulian Age in Europe, found in the same section at another level, a subsequent culture was deduced, this being characterised by implements of the Mousterian type.

These finds were considered to establish that development in the art of fashioning tools had proceeded along lines parallel with those in Europe.

SOME FACTORS IN THE NATURAL CONTROL OF THE WATTLE BAGWORM.

By S. H. Skaife, M.A., M.Sc.

With Fifteen Text Figures.

Read July 15, 1920.

The life-history of the wattle bagworm, *Acanthopsyche junodi,* Heylaerts, has been studied in detail by Messrs. Fuller and Hardenberg, and an account of their studies is contained in the publications listed at the end of this paper. When I took over the investigations of the wattle insect early in 1919 little remained to be learned concerning the life-history of the bagworm, the worst of the pests of the black wattle, hence my attention was turned particularly to the study of the natural enemies of this insect. Among the manuscript notes transferred from New Hanover to the Cedara School of Agriculture were some valuable records made by G. C. Haines, whilst assistant to Hardenberg. Haines had collected large numbers of bagworms at intervals, and had carefully examined each one and recorded its condition at the time of examination. More than thirty-five thousand records had been made in this way, but these had never been totalled or abstracted. I wrote to Haines, and he generously gave me permission to complete his work and make use of it. During the past eighteen months numbers of bagworms (500 to 1,000) have been collected at intervals in the plantations around Pietermaritzburg. These have been examined carefully, and records similar to the above kept of them. Altogether nearly 60,000 bagworms have been examined by Haines and myself, and a broad outline of the results obtained are given in this paper.

As the bagworm is an indigenous insect, one may reasonably expect to find that it has many natural enemies, and such is indeed the case. The natural checks include two or three diseases, seven or eight insect parasites, and various predaceous enemies. That these enemies form efficient checks is shown by the fact that the bagworm is effectively controlled by them in normal days, despite its enormous powers of reproduction. According to Hardenberg, the average number of eggs laid per female is 2,300, yet it is only occasionally that severe outbreaks occur, when the plantations are defoliated and serious losses entailed.

Predaceous Enemies.

Large numbers of the newly-hatched larvae are destroyed before they have an opportunity of forming their bags. Hardenberg mentions " a small grey spider which enters the bag and destroys its occupants even before they have left their

hatching place." He also records the fact that the young bagworms are preyed upon by several species of jumping spiders, *Attidae*, just after leaving the parental bag.

The young larvae are dispersed by wind, bird and insect agency, and many of them must die of starvation through being carried away to places where they cannot find suitable food. Those that survive these early perils and manage to construct their bags enjoy a certain amount of immunity for a time, as they are small, inconspicuous, and well protected from their minor enemies. Later in the season, however, the bags are conspicuous objects, and numbers of the larvae fall a prey to birds and rats. The birds that prey upon the bagworm include sprews (Pegler), parrots, weaver birds and the little silver-eyed bird of the thorns (Fuller), the yellow weaver bird and the butcher bird (Hardenberg). These birds pluck the larvae out of the bags whilst they are feeding. The rats (*Mus coucha* and *M. natalensis*, according to Hardenberg) tear open the bag with a characteristic semicircular slit and extract the larvae and pupae through the holes thus made. Hence, in a lot of bags collected in a plantation one can determine with a fair amount of certainty how many larvae have been destroyed by birds and how many by rats. The number of empty bags that are clean and unsoiled (the bagworms will leave soiled bags of their own accord) give an idea of the number of larvae that have been eaten by birds, and those that have been torn open give the number destroyed by rats. The figures below are not a true guide as to the number of larvae killed by rats, as the rats generally remove the bags from the trees before tearing them open, and the bags included in the counts were all gathered from the trees.

Date.	Locality.	No. of Bags Examined.	Destroyed by Rats.		Destroyed by Birds.		Collector.
			No.	Per cent.	No.	Per cent.	
April–Sept., 1914 ...	Clan Syndicate	17,742	152	1	104	1	Haines.
June, 1916	Baynes Drift ...	600	5	1	23	4	Haines.
Mar. Oct., 1916 ...	New Hanover	16,345	44	0·25	78	0·5	Haines.
Mar. June, 1920 ...	Mountain Rise	12,700	98	1	73	0·5	Skaife.
Mar.–June, 1920 ...	Hilton Road ...	800	3	0·5	14	2	Skaife.
Mar.–June, 1920 ...	Town Hill ...	11,500	37	0·25	56	0·5	Skaife.
Totals ...		59,687	339	0·57	348	0·58	

From the above figures it would seem that rats and birds are practically negligible as factors in the control of the wattle bagworm. But, in addition to the fact that the totals do not

include bags removed from the trees before the contents were devoured, all the above bags were collected in well-grown plantations in which there was little or no undergrowth. Fuller records instances where young plantations have been almost entirely freed from bagworms by the rats alone. It would seem that in young plantations overgrown with weeds the rats find plenty of shelter and are abundant, but that in mature plantations, where there is very little cover for them, they do little good in keeping down the bagworms.

PARASITIC INSECTS.

According to Hardenberg there are eight different species of insects parasitic on the bagworm, two ichneumons, one chalcid, and five tachinids, but he had none of these determined, nor were their habits studied in detail. I have only come across two of these parasites, an ichneumon, *Philopsyche abdominalis*, Morley,* and a tachinid, *Carcelia evolans*, Wied.* The tachinid is in its turn preyed upon by a minute chalcid, which has, so far, not been determined.

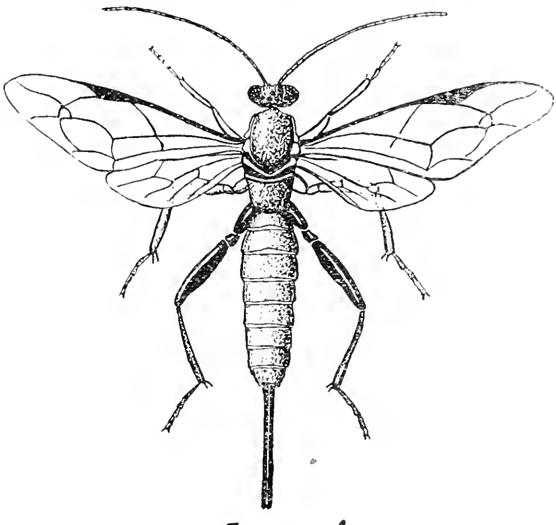


FIGURE 1

Fig. 1.—*Philopsyche abdominalis*, Morley. Female.

Philopsyche is a genus, the members of which seem to restrict their attention to the larvae of psychid moths. The only host so far recorded for *P. abdominalis* is the wattle bagworm. The adults vary considerably in size, but the males are generally about 12 mm. in length, and the females (including the ovipositor) about 20 mm. The head, thorax and hind legs are black, the abdomen red, and the forelegs yellowish white (Fig. 1).

* Determined by Dr. Péringuey.

Our knowledge of the life-history of this parasite is as yet incomplete. There seems to be two generations a year, for full-grown larvae and also pupae were found in bags in March, and eggs and young larvae in April. The period over which the adults emerge is prolonged, and the two generations overlap. Records made by Haines and myself show that adults emerged continuously from March to October. Individuals kept in cages and fed on honey and water have lived for two to three months. Although numbers of bagworms were placed in the cages with the parasites, on only one occasion did a female oviposit in one of the bags, and I was fortunate enough to witness the event. She thrust her ovipositor through the sides of the bag from two or three different positions, and then left it. The whole process occupied less than three minutes. On opening the bag the contained larva was found to be limp and apparently dead, and a large yellow egg (Fig. 4) was found adhering to the side of the bag. This egg hatched in three days, but unfortunately the young larva (Fig. 5) died soon after it was hatched.

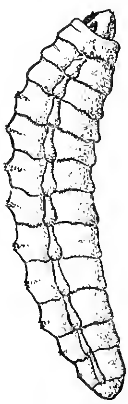


Fig. 2

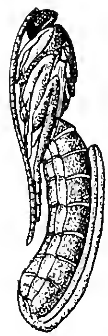


Fig 3

Fig. 2.—*Philopsyche abdominalis*, Morley. Mature larva.
Fig. 3.—*Philopsyche abdominalis*, Morley. Pupa, female.

The larva is an external parasite throughout its life, and can move freely in the bag. It does this by means of the rows of curved spines which arm the dorsum of each of the abdominal segments (Figs. 2 and 7). These spines catch in the silken sides of the bag and also serve to hold it securely in position whilst feeding. The mandibles are well developed, simple, and taper to a sharp point (Fig. 6). In the mature larva they measure 70 μ in length by 30 μ across the base. The chitinised framework of the mouth-parts and the pigment spots on the head of this larva are peculiar and enable one to recognise it readily (Fig. 8).

The pre-pupal stage lasts for two or three days and the pupal stage ten to fourteen days. The larva does not spin a cocoon before pupating, but roughly binds itself against the

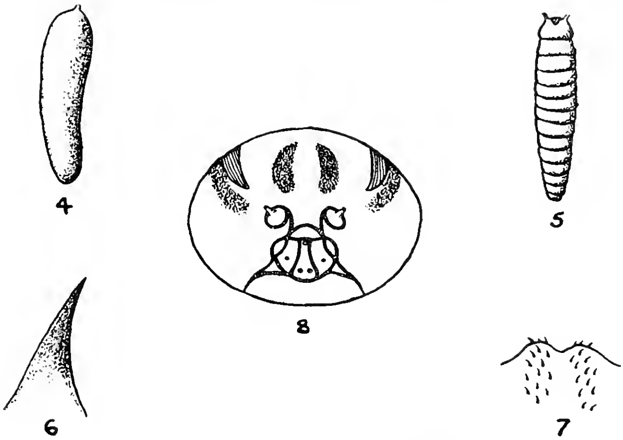


Fig. 4.—*Philopsyche abdominalis*, Morley. Egg.
Fig. 5.—*Philopsyche abdominalis*, Morley. Newly-hatched larva.
Fig. 6.—*Philopsyche abdominalis*, Morley. Mandible of larva.
Fig. 7.—*Philopsyche abdominalis*, Morley. Spines on abdominal segments.
Fig. 8.—*Philopsyche abdominalis*, Morley. Head of larva, front view.

side of the bag by means of a few silken threads. In the female pupa the ovipositor is curved over the back, but in the adult this appendage is always directed posteriorly (Fig. 3).

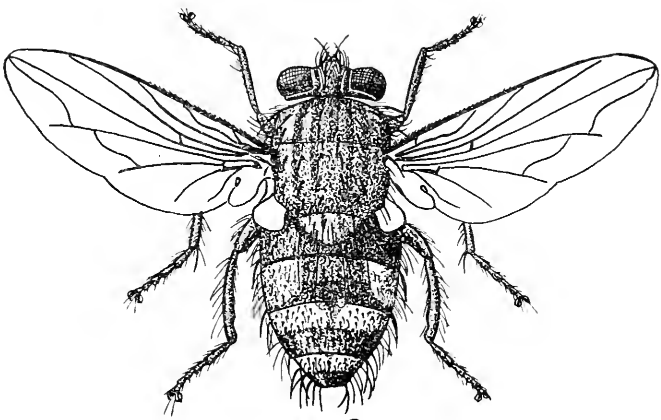
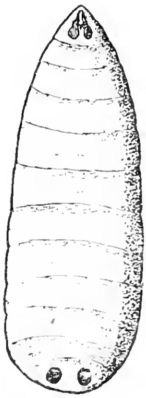


FIG. 9.

Fig. 9.—*Carcelia evolans*, Wied. Adult female.

Carcelia evolans is the commonest of the tachinid parasites of the bagworm. The eggs are found glued on the

exterior of the host's body, generally on one of the thoracic segments, and are apparently placed in position whilst the host is feeding. Some bagworms may bear three, four, or five of these eggs, although only one parasite can come to maturity in a single host. The eggs are dull white in colour, oval in shape, and measure 0·75 mm. by 0·5 mm. (Fig. 12). The larva of this species can be easily recognised by its peculiar buccal armature (Fig. 14), by the irregular rows of spines running transversely across the anterior border of each segment (Figs. 10 and 15), and by the arrangement of the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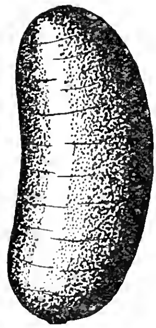
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Fig. 10.—*Carcelia evolans*, Wied. Mature larva.
Fig. 11.—*Carcelia evolans*, Wied. Puparium.

slit-like orifices in the stigmata (Fig. 13). The parasitic larva leaves the body of its host when fully grown and pupates inside the bag as a general rule, although there are indications that a few of them may drop to the ground and pupate in the soil. The puparium is blackish brown in colour, slightly curved, and measures about eight millimetres in length (Fig. 11).

Like *Philopsyche*, the emergence of the adults extends over a long period, from March to October, and the generations, probably two a year, overlap. The adult is a burly, hairy fly, measuring about ten to twelve millimetres in length. The eyes are bright red and the frons silvery in colour. The body is dark grey, with four indistinct black lines on the thorax. The scutellum is deep brown. A conspicuous silvery band runs transversely across the anterior half of each of the abdominal segments from the second to the fourth; the band on the third segment is more distinct than the others. On each side of the second segment there is an indistinct reddish patch (Fig. 9).

Both Fuller and Hardenberg have recorded a secondary parasite from this fly. This is a minute chalcid, as yet undetermined, metallic green in colour, and measuring two millimetres in length. The adults emerge from the puparium through a neat round hole which they eat out of the side. From one puparium, found at Mountain Rise, near Pietermaritzburg, 145 of these secondary parasites were reared, 117 males and 28 females.

Hardenberg states that the percentage of flies found parasitised by these little wasps is small, and its effect in reducing their numbers is negligible. But this does not agree with my observations. Out of 87 puparia found in bags collected at Mountain Rise in April last, 54, or 62 per cent., were found to have been destroyed by this chalcid.

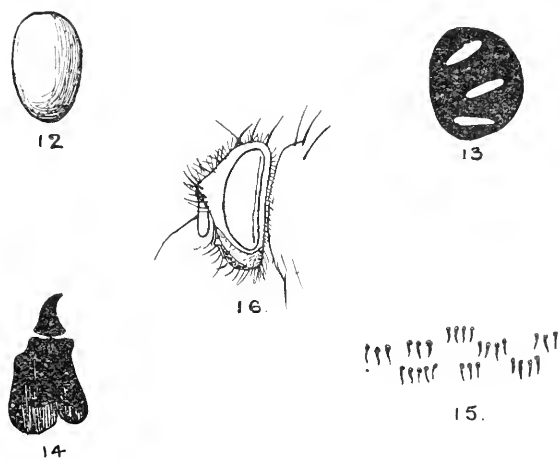

Fig. 12.—*Carcelia evolans*, Wied. Egg.
Fig. 13.—*Carcelia evolans*, Wied. Stigma, showing slit-like orifices.
Fig. 14.—*Carcelia evolans*, Wied. Buccal armature of larva.
Fig. 15.—*Carcelia evolans*, Wied. Larval setae.
Fig. 16.—*Carcelia evolans*, Wied. Profile of head of adult.

In examining bags to determine the percentage of parasitism it is fairly easy to distinguish individuals that have been killed by a Hymenopteron from those destroyed by a Dipteron, even though the adult parasites have emerged and flown. The empty pupal skin of the ichneumon can generally be found beside the shrivelled remains of the host, and there is often a small, round hole bitten in the lower side of the bag through which the adult has emerged. In the case of tachinid parasitism, the empty puparium is left behind in the bag. Of course, where immature stages of the parasites are present, there is no difficulty in determining their identity. In the figures

given below, Haines' records probably refer to more than one species of parasite in each case, but the records collected by myself refer only to the two parasites mentioned above.

Date.	Locality.	No. of Bags Examined.	Dipterous Parasitism.		Hymenopterous Parasitism.		Collector.
			No.		Per cent.		
April–Sept., 1914 ...	Clan Syndicate	17.742	2.848		16		Haines.
June. 1916	Baynes Drift ...	600	334		56		Haines.
			No.	Per cent.	No.	Per cent.	
Mar.–Oct., 1916 ...	New Hanover	16,345	900	5·5	2,858	17·5	Haines.
Mar.–June, 1920 ...	Mountain Rise	12.700	629	5	1.865	14·7	Skaife.
Mar.–June, 1920 ...	Hilton Road ...	800	10	1·25	16	2	Skaife.
Mar.–June, 1920 ...	Town Hill ...	11,500	385	3·3	1,379	12	Skaife.
Totals ...		41,345	1,924	4·7	6,118	14·8	

The above figures show that an average of about 20 per cent. of the bagworms that survive the early perils of their life are destroyed by insect parasites, but they also show that this percentage varies greatly in the different localities. This variation seems to have a direct relation to the degree of infestation of the plantations in which the insects were found. At Hilton Road, where the infestation was very slight and it was difficult to collect any number of bagworms, the parasitism was only just over 3 per cent., whereas at Mountain Rise, a heavily infested plantation, nearly 20 per cent. were parasitised. The figures also show that the hymenopterous parasites are more than three times as efficient as the tachinid parasites.

Diseases.

The fungous disease of the bagworm, caused by the parasitic fungus, *Isaria psychidae*, Pole Evans, is well known owing to the researches of Dr. Pole Evans, who studied this disease and initiated some preliminary experiments in its artificial dissemination. Owing to pressure of other work, Dr. Pole Evans was unable to follow up his studies, and the work was taken up at Cedara. The results of observations made during the past eighteen months will be embodied in a later paper. The efficiency of this highly virulent fungus as a check on the bagworm is somewhat impaired by the attacks of a secondary parasite, another fungus known as *Melanospora parasitica*. The *Melanospora* grows upon the *Isaria*, and partially or wholly inhibits the conidia formation of its host, thus curtailing the spread of the disease.

Another virulent and highly destructive disease of the bagworm is caused by a filterable virus, and is very similar in its nature to the "polyederkrankheit" of silkworms and nun

moth larvae in Europe and to the polyhedral wilt disease of gipsy moth larvae in America. Some specimens of diseased bagworms were sent to Dr. Glaser, the American authority on wilt disease, and he wrote back to me that the larvae were undoubtedly affected with polyhedral wilt disease.

A larva affected by this disease can be recognised by the distended appearance of its body and by its pale colour. If such a larva be pricked with a needle a drop of milky white fluid will issue from the puncture thus made, quite different in appearance from the colourless blood that issues from a similar puncture made in a healthy individual. Under the high power of the microscope this white fluid is found to contain myriads of minute, highly refractive bodies known as polyhedra. These polyhedra are mostly square or triangular in outline, and have slightly rounded corners. They measure 0·5 μ to 2·5 μ across, the average breadth being about 1·5 μ. They originate in the nuclei of the tracheal matrix, hypodermal, fat and blood cells, and are, according to Glaser, probably reaction bodies belonging to the nucleoproteids. The nuclei containing these bodies swell up enormously and eventually burst, setting the polyhedra free in the blood. Thus the tissues disintegrate and the blood becomes crowded with the polyhedra, which gives it the milky appearance mentioned above. At this stage the larva dies, the alimentary canal disintegrates, the colour of the body changes to a deep brown, and the corpse finally dries up until it is nothing but a scale adhering to the side of the bag. At no stage in the disease is the body filled with a brown fluid, the skin does not break easily at a touch, nor does the diseased larva hang by its prolegs. In these respects the disease differs from the wilt disease of gipsy moth caterpillars, silkworms and other larvae.

Many experiments with this disease have been carried out at Cedara, but only two will be mentioned here. The bodies of several larvae that had died of wilt were emulsified in sterile water, and this fluid was sprayed on to some wattle foliage by means of an atomiser. This infected foliage was fed to fifty bagworms, and in the course of three weeks all died of wilt. In all these experiments only those caterpillars which showed typical polyhedral bodies in their blood were considered to have died of wilt. The first larva to die of the disease died ten days after being fed on the infected foliage, but the majority of them died in the third week from the commencement of the experiment. In a control cage containing fifty bagworms that had been fed on clean foliage only eight died of wilt disease.

In another experiment the emulsified bodies of ten larvae in two hundred cubic centimetres of sterile water were filtered first through a filter paper and then through a Berkefeld filter. This filtrate, which was quite free of polyhedra and bacteria, was sprayed on to wattle foliage as before and fed to fifty bagworms. Within five weeks twenty-seven died of wilt, the first one dying seventeen days after the commencement of the experiment, but the great majority died during the fourth week. In the control cage only ten of the larvae died of wilt.

These two experiments cannot be regarded as conclusive, but they indicate that the disease is contracted through the ingestion of contaminated food and that the virus is filterable. One difficulty has still to be cleared up, and that is the manner in which the disease is spread in Nature. The larva dies and dries up inside the bag, hence it is difficult to understand how the foliage becomes contaminated with the virus of the disease, unless it be through the faeces, but the alimentary canal is the last of the organs to be attacked, and no polyhedra are found in the intestine right up to the death of the larva.

There are other diseases of an obscure nature to which the bagworm is liable. The affected larvae die and disintegrate into an evil-smelling liquid, which soils the bags and teems with bacteria. Whether these diseases are due to bacteria or to disturbances in the normal physiological functions, or both, is at present underternined. On several occasions I have come across sickly larvae which, on being disturbed, have discharged a drop of brownish liquid from their mouths. This fluid is found to contain large numbers of bacteria, the great majority of which are bacilli, with large, oval, terminal spores. These larvae die and disintegrate as above, but, until the bacteria have been isolated in pure culture and inoculation and feeding experiments performed with them, no definite assertion can be made as to the existence of a bacterial disease.

In the figures given below all the bagworms that have died of diseases other than the fungous disease are added together. This is unavoidable, as Haines' records do not distinguish between wilt and other diseases, but I have records which show that of the bagworms collected at Mountain Rise 6 per cent. were killed by wilt disease, and of those collected at Hilton Road no less than 19 per cent. died of this disease.

Date.	Locality.	No. of Bags Examined.	Killed by Fungus.		Killed by Other Diseases.		Collector.
			No.	Per cent.	No.	Per cent.	
April–Sept., 1914 ...	Clan Syndicate	17,742	3,292	18·6	3,971	22·3	Haines.
June, 1916	Baynes Drift ...	600	18	3	56	9·3	Haines.
Mar.–Oct., 1916 ...	New Hanover	16,345	528	3·2	1,851	11·3	Haines.
Mar.–June, 1920 ...	Mountain Rise	12,700	4,376	34·5	2,359	18·6	Skaife.
Mar.–June, 1920 ...	Hilton Road ...	800	15	2	321	40	Skaife.
Mar.–June, 1920 ...	Town Hill ...	11,500	1,283	11·1	1,368	12	Skaife.
Totals ...		59,687	9,512	16	9,926	17	

Although the climatic conditions at Hilton Road are such that one would expect the fungous disease to flourish there, only 2 per cent. of the 800 bagworms examined were found to have succumbed to this disease. This would appear to be entirely due to the scattered manner in which the bagworms

were spread through the plantations, a condition which militates against the spread of the disease. On the other hand, 40 per cent. were destroyed by other diseases in this locality, and this would seem to indicate that the virulence of these diseases is largely dependent on the climatic conditions. At Hilton Road mists are almost of daily occurrence during the summer and thunderstorms are frequent. The excessive humidity during the warm months either sets up physiological disturbances which cause the death of the larvae, or else weakens them and renders them peculiarly liable to disease.

Summary.

Out of a total of 59,687 bagworms examined, just over 1 per cent. were destroyed by birds and rats, 19 per cent. by insect parasites, 16 per cent. by fungous disease, and 17 per cent. by other diseases, making a total of 53 per cent. destroyed. Despite the enormous numbers killed by the above agencies, the figures show that a far greater mortality must take place in the younger stages, from September to March. Hardenberg estimates that, of the bagworms which reach sexual maturity, the majority are males, there being an excess of males over females of about 25 per cent. This agrees with my own observations. Therefore, of the 47 per cent. that survive, only 21 per cent. will be females; in other words, out of every hundred bagworms found in the plantations in March only twenty-one females will reach sexual maturity. These females will deposit some forty to fifty thousand eggs, which will hatch in the following spring. Assuming no yearly increase on the part of the bagworms, these forty to fifty thousand will be reduced to one hundred by March, that is to say, only one-quarter of 1 per cent. of the larvae hatched survive the early perils of their life. Even if we assume a hundred per cent. yearly increase, only one-half of one per cent. can survive until March. Thus it will be seen that this early mortality, about which very little is known, is by far the most important of the factors in the natural control of the wattle bagworm.

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MAP OF SOUTH AFRICA, SHOWING THE CHIEF NATIVE LANGUAGES AND DIALECTS.

By Rev. G. Beyer.

Read July 17, 1920.

Explanatory Remarks.

By "South Africa" is meant the country lying south of the Cunene-Okavango-Zambesi Rivers.

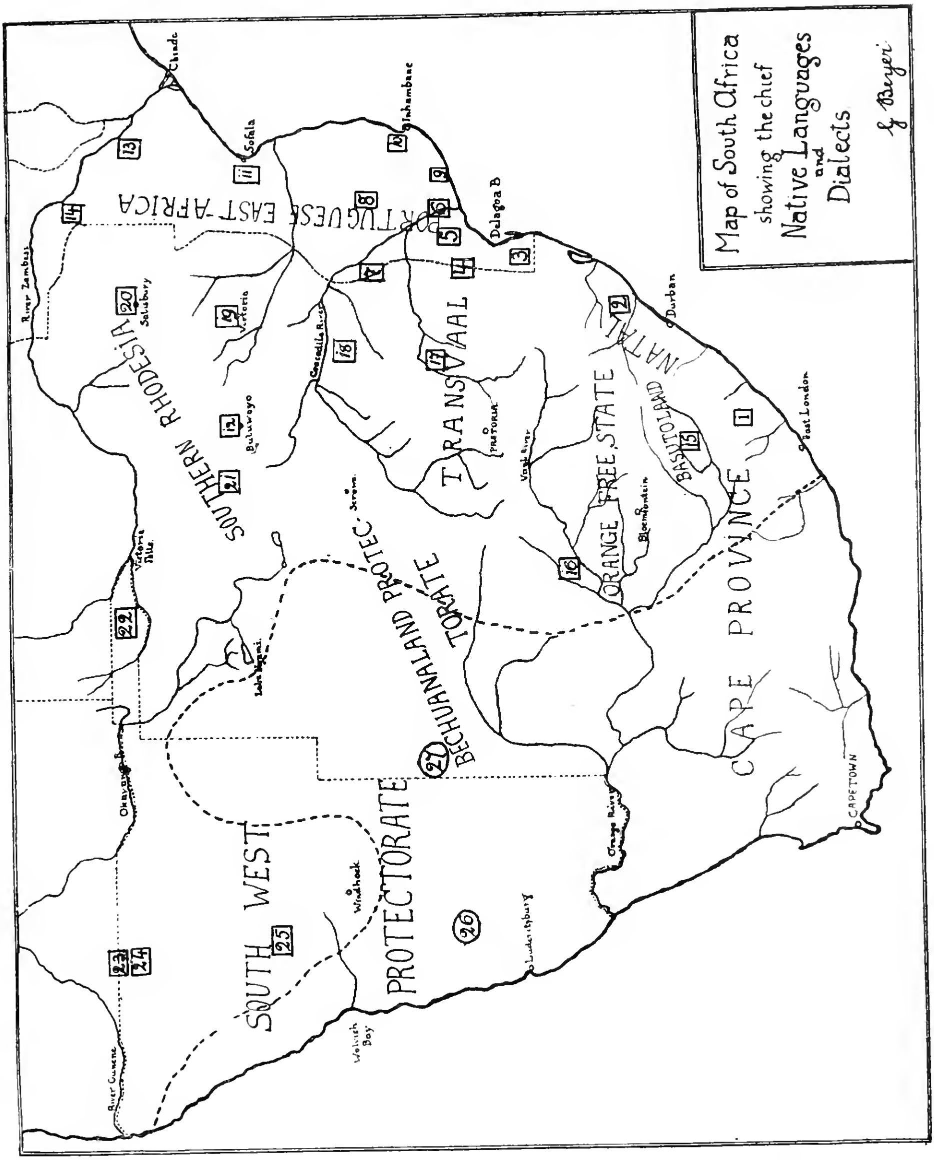
The dotted serpentine line stretching from the vicinity of East London in a north-western direction across South Africa indicates the boundary line of the Bantu to the north-east, and the non-Bantu groups, Bushmen and Hottentot, to the south-west.

The numbers on the map signify the district in which a language is spoken.

The names are given without prefixes, *e.g.*, Se-pedi is written Pedi; it is spoken where the number 17 appears on the map.

The key is as follows:—

Bila (Thonga-Shangaan dialect) ...	6
Bushmen (two different languages and three dialects) ...	27
Chopi ...	9
Chuana (Setlaping, Serolong, Sekgatla, etc.) ...	16
Djonga (Thonga-Shangaan dialect) ...	5
Herero (Damara) ...	25
Hlanganu (Thonga-Shangaan dialect) ...	4
Hlengwe (Thonga-Shangaan dialect) ...	8
Kalana ...	21
Karanga ...	19
Kuanyama ...	23
Mashona ...	20
Nama (chief Hottentot dialect) ...	26
Ndonga ...	24
Nwalungu (Thonga-Shangaan dialect) ...	7
Pedi (Northern Sotho) ...	17
Ronga (Thonga-Shangaan dialect) ...	3
Sena ...	13
Sofala ...	11
Sotho (Suto proper) ...	15
Subia ...	22
Tebele ...	12
Tette ...	14
Tonga ...	10
Venda ...	18
Xosa (Kafir) ...	1
Zulu ...	2



Map of South Africa
showing the chief
Native Languages
and
Dialects
SOUTHERN RHODESIA
PORTUGUESE EAST AFRICA
TRANSVAAL
ORANGE FREE STATE
NATAL
BASUTOLAND
CAPE PROVINCE
BECHUANALAND PROTECTORATE
SOUTH WEST
PROTECTORATE
Salisbury
Victoria
Buluwayo
Sofala
Inhambane
Chinde
Delagoa B
PRETORIA
Bloemfontein
Durban
East London
CAPETOWN
Windhoek
Luderitzbury
Walvish Bay
Victoria Falls
Lake Ngami
River Zambesi
River Cunene
Okavango R.
Orange River
Vaal River
Crocodile River
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NOTES RELATING TO ABORIGINAL TRIBES OF THE EASTERN PROVINCE.

By John Hewitt, B.A.,
Albany Museum, Grahamstown.

With Plates XXXI, XXXII.

Read July 17, 1920.

Relics of a Pre-Bush Race?

On the evidence of stone implements it seems likely that our historic aboriginals were preceded by another race or races. The former, as we learn from examination of "Bushman" caves, were skilled in making the implements known as "end-scrapers," and various other types less characteristic. But the implements occurring deeply embedded in the ironstone gravel of the subsoil at Grahamstown and elsewhere are of quite a different type. There are no end-scrapers, nor other implements with secondary trimming, but instead we find an abundance of simple flakes, all large and coarse. Such flakes are generally regarded as rejected material produced in the making of larger implements of the palaeolithic type. Indeed, typical "bouchers" and other palaeoliths are sometimes found in these gravels at Grahamstown. However, regarding the antiquity of such relics, no positive estimate should be made. The gravel in which they occur has been formed *in situ*, and is not necessarily very old. It contracts during drought and expands in wet seasons, so that overlying objects, if sufficiently heavy, may quickly sink therein to considerable depths. But in favour of their antiquity is the fact of their identity with the implements made by primitive man in Europe, during a warm inter-glacial period, estimated by various authorities as at least 150,000 years ago. This was in the time of Neanderthal man, prior to the appearance of *Homo sapiens* in Europe. Moreover, a very respectable antiquity may be fairly claimed for similar specimens found in ancient river beds on the Vaal River and in the Western Province.

Strandloopers.

Relics of bygone races are plentiful in and near the extensive shell-mounds that fringe the coast near the mouths of rivers. The mounds are the accumulated refuse of the so-called strandloopers, who fed on shell fish and other products of the sea. Some idea of the magnitude of such coastal middens may be gained from G. R. McKay's paper on the "Antiquity of Man in South Africa." He tells us that upwards of 375,000

cubic feet of shells were removed to fill up the lagoon behind the east training wall at East London, and that the mound was 150 feet long and 40 feet deep, covered with vegetable soil and with trees growing on it.

There is little historical evidence relating to the strandloopers of the Eastern Province, although they were seen at the very earliest date of our history by Bartholomew Dias.* At the present day, according to Rogers, in his "Geology of Cape Colony," such mounds are being made by Kaffirs in the Transkei and Pondoland. The natives collect the shells, carry them to a convenient spot close to the shore, and there remove the edible portions, which they take back to their kraals in baskets or cloths, leaving the shells behind. In this way astonishingly large piles of more or less broken shells accumulate in course of time. Near Port Alfred a few Kaffirs may usually be seen collecting shell-fish off the rocks at low tide, and Mr. A. E. Cronwright informs me that "when food is scarce the wives and children of the Bantu servants hereabouts always repair to the sea during times of spring tides, each with a sack and some sort of rude line to wrench the shells from the rocks. They will travel miles to do this, and carry their full bags back on their heads a few hours later." However, it is doubtful if the habit prevailed amongst the earliest Kaffir invaders, for many writers have testified to the fact that the primitive Kaffir did not eat fish or shell-fish, regarding them as unclean. On the other hand, the strandlooping habit in the Western Province was characteristic of some degraded Hottentot or Bushman tribes who are now extinct. The term "strandlooper" or "watermans" was first applied by the

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* "The fourth (negress) remained in the Bay of the Islets of Santa Cruz, with two others whom they found there collecting shell-fish, and they would not carry them away because the King commanded them not to offer violence or give cause of offence to the inhabitants of the lands they should discover.'—From De Barros in "Asia."

There is a much earlier reference to strandloopers on the East African coast. Edrisi, an Arab writer of the twelfth century, A.D., says: "This country (Sofala) touches that of Ouac-Ouac, where are miserable towns. The natives are black, of hideous figure and deformed complexion; their language is a species of hissing. They go absolutely naked and are little visited by strangers, and they live on fish, shell-fish and tortoises." The Ouac-Ouac, or Wak-Wak, have been identified by recent authorities with the Hottentots, as if their name were merely the Arab rendering of Khoi-khois. This seems important, for the Wak-Wak of Edrisi were clearly strandloopers, like the Watermans of the Cape, at any rate in habit. They were certainly not Bantu, who for centuries had been well known to Arab traders under the name of Zeng or Zindj. Other suggestions have, however, been made regarding the origin of the word Wak-Wak; and the Islands of Wak-Wak, mentioned in the story of Ali Hassan as seven years' journey from Bagdad, have been variously placed as the Seychelles, Madagascar, Java and Japan.

According to Mr. Hammond Tooke, the region referred to by Edrisi must be south of the Zambesi, but north of the Limpopo; but, according to a foot-note in L. C. Smithers' edition of "Burton's Arabian Nights," vol. vi, p. 217, the locality in question is the peninsula of Guardafui. The former interpretation agrees better with the statements of Mas'oudi (A.D. 943), the land of the Wak-Wak adjoining that of Sofala.

Dutch settlers in Van Riebeek's time to a very small tribe of destitute people who were otherwise known as the Goringhaikona* Hottentots. They do not seem to have been regarded as racially distinct from the pastoral tribes of the same neighbourhood, and their language was Hottentot (W. Hammond Tooke).

In the Eastern Province the coastal shell mounds may have received contributions from Kaffir tribes, for the Kaffirs occupied our coast during the latter decades of the eighteenth century, but the implements and pottery of the shell-mounds afford definite evidence of cultural relationship with the strandloopers of the Western Province, whose arts have been made known mainly through the writings of Dr. L. Péringuey (see his "Stone Ages of South Africa"). Pottery of the same superior type as that designated strandlooper by Dr. Péringuey has been found quite near to the shell-mounds of the Port Alfred neighbourhood. I refer specially to the large wide-mouthed vessels of ovoid-conical shape, tapering to a pointed base. Similar pots have been found also at inland localities: one such pot was recorded by Dr. Péringuey from the Zuurberg, and I have lately seen broken pieces of pottery, clearly of strandlooper technique, found along with calcined mussel shells by the Rev. P. Stapleton, S.J., at Dunbrody, near the Sundays River, under circumstances pointing to great antiquity (*vide* SOUTH AFRICAN JOURNAL OF SCIENCE, 1919, p. 230). Perfectly typical strandlooper pottery is also known to me from rock-shelters at Grahamstown and Alicedale. Strandlooper artefacts therefore were not confined to the coast.

The stone implements of the coastal shell-mounds are of various types, principally simple flakes, but including an occasional scraper with secondary chipping similar to those which occur in the inland rock-shelters. For instance, we have specimens of the same peculiar type—an elongated burin of Aurignacian facies from a shell-mound at Kleinemond, near Port Alfred, and from a locality near Britstown.

Amongst the various types of implements found on coastal sites there is perhaps only one which has not yet been found at inland localities. The technique has long been known from some finely trimmed lance-heads found on the Cape Flats, and, according to Geo. Leith ("Journal of Anthropological Institute," N.S., vol. i, p. 258 *et seq.*, 1899) "some very beautifully

* "Among the ugly Hottentot race there is yet another sort called the Goringhaikonas. Harry was the chief, or captain, of these; we have them daily in our sight and about our ears, within and without the fort; they possess no cattle, and live by fishing from the rocks. A few years since they were only 30 in number, now they consist of 70 or 80, including women and children, having been joined by similar rabble from the interior. By night they live in little hovels in the sand-hills; by day they may be seen, sluggards as they are, assisting the burghers in scouring, washing, cutting wood, fetching water and herding sheep, etc. Others of the lazy crew who will not work at all live by begging, or seek their subsistence by stealing and robbing on the common highways.—From "Mr. Wagenaar's Memorandum," A.D. 1666.

formed implements, chiefly scrapers, in chert, jasper, agate and chalcedony, which will compare favourably, as regards form and finish, with the finest European or American examples," were found at Port Alfred. The Albany Museum has no specimens from Port Alfred that agree with this eulogistic description, but several specimens from Kleinemond (Dr. W. G. Atherstone) seem to conform to the Cape Flats type, and quite recently some markedly superior implements (proto-solutric) have been found at the Kasouja River mouth by the Rev. P. Stapleton, S.J. Yet this latter type, which is very characteristic, is also known to me from a rock-shelter ornamented with paintings in the Grahamstown neighbourhood, and it seems reasonable to expect that future discovery will yield at inland localities the same advanced technique as is at present known only from coastal sites. Traces of a type allied to the European neolithic have indeed been found inland. One of them from Vaalkrantz, near Grahamstown, takes the form of an axe-head, or adze, with well-ground cutting edge, and another from a rock-shelter at Spitzkop, near Alicedale, also with ground cutting edges, seems to have been a lance head, yet not equal in form and finish to European neoliths.

The similarity in culture of the strandloopers and the cave men is not limited to their pottery and implements,* for the inland cave-dwellers were evidently fond of shell fish. In most of their shelters around Grahamstown, generally ornamented with "Bushman" paintings, quantities of fresh-water mussel shells occur in the débris of the floor. Also at various places far inland, as at Cradock, there are relics of veritable strandloopers on the banks of rivers, their heaps of mussel shells containing bits of pottery quite like those from the coast.

Another fact of interest as showing a direct connection between the cave-dwellers and the coast is the frequent presence of marine shells within the caves. Such marine shells have been found in rock-shelters both at Alicedale (C. W. Wilmot) and Grahamstown.

Of late years some confusion has arisen owing to the restriction of the term "strandlooper" to a particular physical type. Following Dr. F. C. Shrubsall, the physical anthropologists use this term in reference to a homogeneous race, of Bushman affinity, whose skeletons have been found in the caves of George, Knysna and Humansdorp. They are ultra-Bush in skull characters, being more brachycephalic and more orthognathous than any other tribe in South Africa. Skulls from the same caves had previously passed as typically Bushman. These same people moreover, like the ordinary Bushmen,

* According to Dr. Péringuey, the large palaeolithic implements were also made by strandloopers, yet they do not seem to occur in our coastal middens and none have been taken in the local caves, so that their connection with the historic aborigines is uncertain in this region. We have typical specimens of bouchers and of "haches à talon" from Alicedale presenting a singularly fresh appearance, and others from Grahamstown greatly weathered. Yet in neither case does the state of the specimen warrant an estimate of age, the nature of the stone being the dominant factor in weathering.

were rock-painters, thus differing apparently from the pastoral Hottentots. They are considered to represent the earliest and purest type of Bushman, whilst the ordinary inland Bushman, and possibly also the Hottentot, have diverged therefrom through admixture with other stocks.

Historical Data Relating to Hottentots.

Immediately prior to the advent of Europeans in the Eastern Province, the region between the Sundays River and Great Fish River was sparsely populated by a pastoral race called Gonaqua, by vagrant bands of Kaffirs, and perhaps even by remnants of Bushman tribes. It may have been some part of this region, the country near to Sand Flats, that was referred to by Paterson* in 1779 as "the Boshmen's land," but he does not seem to have actually met Bushmen in the course of his travels through lower Albany.

It seems probable that for centuries the inhabitants of this region were mainly pastoral Hottentots. So long ago as 1622 A.D., the crew of the wrecked ship "S. Joao Baptista" obtained pack oxen and milk from coastal Hottentots living between the Great Fish and Kei Rivers. In the time of Governor van der Stel (1689 A.D.) a tribe called Inqua was discovered by Ensign Isaak Schryver, living apparently in the Aberdeen district.† The Inqua were numerous, their captain,

* Writing from the Swart Kops River, Paterson reported: "The next morning we were overtaken by a peasant who was on his way to the Boshmen's Land, and was glad to accompany us as this place lay in our way. The peasant proved to be Jacob Kock, who had a plantation at Sand Fleet." Stow is not justified in saying that Lieut. Paterson explicitly informs us that "the Zuurveld was then called Bushman-land." Jacob Kock's destination was not revealed in the narrative—he may have been going to Kock's Kraal, on the upper portion of the Great Fish River, near to Cookhouse. In any case, if Bushmen had frequented the Bushman's River at that time, such a menace to the pastoral tribes would probably have been mentioned by travellers, for from the earliest days Bushmen and Hottentots seem to have been at enmity with each other. Le Vaillant tells us that the Hottentots advised him to avoid the Bushman's River, in order to "evade a large troop of Caffres who had alarmed the whole canton, spreading destruction wherever they came."

† For a detailed account of the expedition, see "Moodie's Records," p. 433 *et seq.* The site is probably on the Kariega River, head-waters of the Gamtoos, recorded in the narrative as the Kaluiga. On that river there is still a place called Hottentots Bush, and a tributary named Hottentots River. So far as I can ascertain, no writer has indicated a precise locality. In Theal's map of distribution of native tribes in the year 1689, the Inqua are placed between the Sundays and Great Fish Rivers. One of the tributaries of the Sundays River is called the Cuinqua. Does this take its name from the Inqua? The Inqua may have been the same tribe as the Heykom Hottentots, mentioned by Kolben (1713). The Heykoms were said to adjoin the Gamtoos Hottentots in a north-easterly direction, their country being very mountainous and only fertile in the valleys. According to this author, the Damaqua lived in "a country where there was scarce fuel enough to dress their victuals unless they burn a sort of moss; in this country are several salt pits." Thunberg suggested that the Heykoms had at one time inhabited the Long Kloof and Kromme River.

Hykon, had much greater authority than any of the captains about the Cape, and their wealth in stock was considerable, so that Schryver returned to the Colony with more than 500 head of cattle and many sheep received in exchange for the usual trading commodities. Their captain was reported to be "taller and larger than any of our servants; they are in general larger in body than the Cape Hottentots, well proportioned, active and strong, though in countenance and beard they resemble the Cape Hottentots." Between them and the Kaffirs was another Hottentot tribe, the Damaqua, populous, rich in cattle, and dwelling in houses made of clay; they were coastal people, who obtained copper and iron beads from shipwrecked vessels. South of the Inqua, also on the sea coast, were other tribes well provided with cattle: the Ganumqua, Namunqua and Gonuqua, from whom the Inqua obtained dakka. The Kaffirs were then five days' journey from the Inqua, in a direction to the east-south-east; they lived in houses of clay, and possessed much cattle.

Thus the Inqua were not in actual conflict with the Kaffirs, but were constantly at war with their neighbours, the Bushmen. Towards the north they obtained copper from other tribes, recorded as the Gly, Bry and Bly, who were probably Griqua and Bechuana.

Thus it seems clear that Hottentot tribes with their flocks and herds penetrated far into the interior of the country, along the river valleys of the Karroo. How far they ranged along the eastern coast we do not know. Theal suggests that in the year 1500 they were at the Umtamvuna River. Various writers have inferred Hottentot occupation in the more eastern parts of the Cape from the prevalence of characteristic place-names, such as Gonubie or Nahoon, but, according to Stow, such names are actually of Bushman origin. On this point I am not competent to express an opinion. In the most recent paper on aboriginal place- names (SOUTH AFRICAN JOURNAL OF SCIENCE, 1918), the Rev. J. R. L. Kingon does not attempt to discriminate between Hottentot and Bushman words. He tells us that "many names containing Hottentot-Bushman sounds are found as far east as the Umzimvubu and its tributary the Tina, and comparatively few beyond."

However, it is certain that in the early part of the eighteenth century the Hottentot country extended at least as far as the Kei River, for Kaffir tradition tells of bloody battles on that river between Hottentots and the vanguard of the Bantu tribes (*circa* 1740 A.D.), and of the famous Hottentot chieftainess, called Hoho, who reigned in the Pirie forest. Shortly afterwards, when Ensign Butler (1752) made his expedition into the Eastern Province, the Keiskama had become the boundary between Bantu and Hottentot tribes. The eastern Hottentots were then reported to be in great poverty owing to Bushman depredations and Kaffir wars. This explorer found the Damaqua between the Gamtoos and Zwartkops Rivers, and adjoining them, from the Bushman's River almost up to the Keiskamma, was another Hottentot tribe, the Damasonqua,

who were neighbours of the Gonaqua, but not directly related thereto, being an offshoot of the Hoengeijqua.* Apart from Beutler's brief note, history is silent on these early inhabitants of the Albany district, the Damasonqua and their relatives. At that time Captain Ruyter, who eventually obtained dominion over all the Hottentot tribes of the Zuurveld, had not reached the zenith of his power. He and his followers associated with the Damasonqua, but he was not paramount chief.

According to the Rev. John Brownlee (in "Thompson's Travels"), the Gonaqua Hottentots originally had their chief kraals on the coast, and likewise inhabited the country along the Buffalo River and up to the very sources of the Keiskama. Afterwards, when the Caffers took possession of the Zuurveld, the Gonaqua retired northward to the Zuurberg and Bruintjes Hoogte. This took place in the time of Kohla or Reuter, the Gonaqua chief from whom the Zuurveld was purchased—according to Caffer statements—at a high price in cattle, by the Amagqunukwebe clan.

Lieut. Paterson wrote of the Gonaquas as follows:—

> "At a little distance to the eastward (from Sand Fleet) are some kraals belonging to the tribe of Hottentots called Chonacquas. These people are much darker in their complexion and better shaped than any other tribes (Hottentots) I had before seen. Whether this difference arises from their mixing with the Caffres, several of whom dwell in this part of the country, or from any other cause, I could not ascertain. It is not very uncommon for the Caffers and Chonacquas to quarrel, which generally ends in an engagement. In these encounters several hundreds of the Caffers sometimes unite to oppose their enemies, who very seldom bring a proportionate force into the field, but the dexterity with which the Hottentots use their bows and arrows, and the practice of poisoning the latter, render them very dangerous enemies to those who only use the Hassagai. The disputes between these people generally originate about cattle, of which both nations are extremely avaricious. We directed our course eastward to the Boschmans River, and at noon I visited a kraal belonging to a Hottentot captain called De Royter. This man has upwards of 200 Hottentots and Caffres in his service, and a few hours before our arrival had fought against a number of Caffres, had beaten them off the field, and taken many of their cattle."

Thus it seems clear that the Gonaqua were quite distinct from the Western Province Hottentots, with whom the traveller was well acquainted, and from the Caffres whom he met later after crossing the Great Fish River. Though Bushman-like in mode of life, they appear to have been darker and bigger† than the small and yellow Bushmen found near Camdeboo They were indeed called Hottentots by Paterson, but it should be understood that he recognised no racial

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* Probably the same as the Geikhauas (Cauquas), belonging to the Namaqua group of tribes, and regarded as a senior, and, in a sense, paramount clan.

† "The superior size and strength of the Inqua and Gonaqua Hottentots is noteworthy. In the former case, at least, it cannot be due to recent admixture with Bantu tribes. The Namaqua Hottentots of the Clanwilliam district were also described as half-giants compared with the small-made Hottentots of the Cape."—Van Meerhof, 1661.

distinction between Bushmen and Hottentots: to him the Bushman was merely a wilder kind of Hottentot. Certain Chonacquas met by the same traveller during an earlier journey were actually regarded by him as "Boshmens." He wrote of them thus:—

> "In one of my excursions I fell in with a party of these savages. They were armed with bows and arrows, and the captain who was with them had a hassagai or spear in his hand, and heavy ivory rings on his right arm. On my return to the farmer's house I found them to be of the tribe of Chonacaquas."

The best account of the Gonaqua is that given by Le Vaillant, who in 1781 found them living not far from Kok's Kraal on the Great Fish River. It was there he met the Hottentot beauty, Narina. According to this author, they differed from the ordinary Hottentots, several of whom accompanied him in his travels, "by the darkness of their complexions, their noses were not so flat, they were much taller and better proportioned, and, in a word, had a more agreeable appearance and deportment." Referring to the cousin of Narina, he wrote:—"His features were at once manly and pleasing, his height and form unexceptionable; he was altogether the handsomest savage I had ever seen." He was convinced that the Gonaquais must have been originally "the produce of those two nations (Caffres and Hottentots)." They possessed "prodigious quantities" of fat-tailed sheep, goats and oxen, whereas the Caffres who lived on the other side of the Great Fish River had only cattle and dogs, and Bushmen only dogs. They had both assegais and poisoned arrows. But "bow and arrows are the natural and proper arms of the Hottentots," and "of Assegais, the Gonaquais and all other Hottentots never carry more than one." "The only furniture I saw in the country, except their mats and skins, was some very brittle earthenware. Their pottery is chiefly useful in melting the fat of their animals." Milk was kept in finely woven baskets. They made karosses of calf skins. Their dwelling-places were huts like those of Hottentots at the Cape, and arranged in half-circles; there were strongly fenced kraals for the cattle. They were not agriculturists in any sense. There was no division of labour amongst the men, no priests and no physicians; there was a chief, but his office was not hereditary. They were musical people, possessing the "goura," a peculiar stringed-wind instrument, the "rabouquin," a kind of guitar, and the "romelpot," a tom-tom.

During his journey from the Sundays River to the neighbourhood of Somerset East and the Great Fish River, Le Vaillant met no other tribes than Gonaqua. He writes: "All this country is inhabited by hoords of Gonaquais who differ essentially from the Hottentots of the colonies." Roving bands of Caffres were reported to be a continual menace, and the elusive Boshismen were heard of, but he actually met neither. The total population had been greatly reduced by the smallpox epidemic, and probably to greater extent through Kaffir wars, and thus the Gonaqua were by this time but a small

tribe. Le Vaillant wrote: "The country of the Gonaquas which I was exploring might reckon about 3,000 people, on an extent of 30 or 40 leagues, out of which the Hoord of Haabas (the most considerable in the country) contained 400." They lived in constant fear of the Caffres.

Other references to the Gonaqua are found in the writings of Sparrman and Thunberg. The former traveller tells us that the Gonaqua met at Van Staades River (1772) were graziers, and had fields of Caffir corn. Like the Kaffirs, they practised circumcision, but, according to Le Vaillant, such was not the case in the tribe he visited. They were comparatively tall, like the Kaffirs who lived with them. At Sondags River he obtained the services of several Boshiesmen as guides. They were introduced to him by "three old Hottentots, properly speaking of the race of Boshismen, who distinguished themselves by the name of Good Boshismen—probably from the circumstance of their grazing a few cattle and not living by rapine like others of their countrymen." Although Sparrman never met "the Hottentot captain, Ruyter," he mentions him as a remarkable man, who "raised himself to be the chief of a party of Boshiesmen or Hottentot rangers," and who used to "assist the colonists by making slaves of such straggling Boshiesmen as did not live under his jurisdiction." At Little Sundays River Sparrman found a clan of Bastards or Hottentot-Caffres. Thence he travelled to Bushman's River, Assegai Bush, and New Year's Drift without seeing anyone, although Caffres and Hottentots were reported to be wandering about that part of the country. He went on to Hevy, then to Quammedacka Well, and finally reached Agter Bruntjes-hoogte, near Somerset East.

On his return he visited a "craal of Gonaqua Hottentots," just after crossing the Bushman's River, but these people seem to be the same as those he had previously mentioned as Good Boshismen!

C. P. Thunberg, who travelled in 1773, tells us that he was visited at Van Stadens River by people who had a tolerable flock of cattle and who had milk in plenty. Then he speaks of "the Gonaquas Hottentots that lived here and were intermixed with Caffres," etc. Most of them were armed with as many javelins as they could well hold in one hand. Thunberg continued his journey as far as the Sundays River, but between Van Stadens and Sundays River he seems to have seen no native settlements.

From the facts furnished by Le Vaillant and Paterson, it is clear that in those days the Zuurveld and lower portions of the Fish River Valley was the home of the Gonaqua, a pastoral race quite distinct from true Bushmen—or Chinese Hottentots, as they were then called—and there is no evidence that Bushmen occurred there except as almost solitary stragglers. Nevertheless, in his important work on "The Native Races of South Africa," Stow tells us that the people met by Le Vaillant and Paterson were actually Bushmen. He suggests that the rock-paintings found near Salem were the

work of the artists of Ruyter's tribe, and Ruyter himself is represented as " the last great chief of the Coast Bushmen, the one who made the last expiring effort to maintain the independence of his race in that part of the ancient hunting grounds of his forefathers which bordered on the Sea Coast." Yet we know from Sparrman's account that Ruyter was not a native of this region, but came from the Roggeveld as a fugitive slave after murdering his companion. The people over whom he ruled were probably for the most part the impoverished remnants of Gonaqua tribes, driven desperate by ill treatment. At the same time, it seems clear that Sparrman did actually meet several Bushmen at the Sundays River, and I think it a reasonable inference from the somewhat confused narrative that these Bushmen had settled down to a pastoral life with a small tribe of Gonaqua Hottentots.

At the end of the eighteenth century, the aboriginal tribes as independent settlements had entirely disappeared from the regions west of the Great Fish River. John Barrow, who travelled in 1797 and 1798, says: "20 years ago, if we may credit the travellers of that day, the country beyond (*i.e.*, east of) Gamtoos River, which was then the eastern limit of the Colony, abounded with kraals or villages of Hottentots, out of which the inhabitants came to meet them by hundreds in a groupe. Some of these villages might still have been expected to remain in this remote and not very populous part of the Colony. Not one, however, was to be found. There is not in the whole extensive district of Graaf Reynet a single horde of independent Hottentots." Incidentally, we learn from his account that a tribe of several hundred Kaffirs, with their herds of cattle, had established themselves on the banks of the Kareeka, but their abodes were of temporary nature. These people were indeed refugees from Kaffir land.

The fate of the Gonaqua was described by Barrow as follows:—

> "On the upper part of the Bosjesmans River (perhaps near Alicedale) we received a visit from the Chief of the Gonaqua, followed by the last remains of this mixed tribe of Kaffir and Hottentot, consisting of about a dozen people. The name of Gonaqua, like those of the numerous tribes of Hottentots now extinct, is just on the eve of oblivion. Driven out of their ancient possessions in the Zuur Veldt by the Colonists, they yet found an asylum from the father of Gaika in one of the most fertile districts of his kingdom, watered by the river Kaapna. Here they were suffered to remain in quiet till the late disturbances among the Kaffirs. Unwilling to act, or undecided which part to take, they became a common enemy, and those who remained in the country were plundered and massacred by both parties, whilst those who fled across the Gt. Fish River met with the same treatment from the Dutch farmers."

The Gonaqua, however, were not quite exterminated. We hear of them later (1825) in a report written from Chumie mission station by Rev. W. R. Thomson, who refers to them under the name of Ghona. The Ghonas had gradually amalgamated with the Kaffir population, but were still in considerable

numbers. He said they were "the most forward to adopt improvements, thus appearing superior to the native Kaffir."

The decline of the Gonaqua commenced early in the eighteenth century, when confronted by the irresistible Kaffirs, but the loss of their independence dates only from the year 1778, when Governor van Plettenberg extended the boundary of the Colony to the Great Fish River. Before that time, all native tribes east of the Gamtoos enjoyed perfect freedom. The failure of these eastern Hottentots to cope with the advancing hordes of Kaffir invaders is in striking contrast with the rise of Hottentot power in South-West Africa about the middle of last century. It is probable, however, that the racial elements concerned were considerably different. Their collapse in the Eastern Province may be partly attributed to inferior philoprogenitiveness. Whilst the Bantu were extraordinarily prolific, the Hottentots were quite the reverse. Le Vaillant commented on the fact that "a Hottentot is seldom or never the father of six children."

We have seen that historical records prove the occurrence of Gonaqua tribes on the coast of the Eastern Province for more than a century. It is also very probable that these same people were the recent strandloopers of our coast. The evidence is mainly furnished by the statements of present-day Kaffirs. In the native location at Port Alfred, and elsewhere along the coast, there are still to be found people who call themselves "Gona Kaffirs." They are generally regarded merely as cross-breeds between Kaffirs and Hottentots, but most probably include remnants of the original Gonaqua race. It is these Gona Kaffirs who are specially fond of a shell-fish diet. According to information received from Mr. E. Jordan, who carefully questioned an intelligent Gona on this point, all the Gona Kaffirs eat shell-fish, regarding it as their natural food. On another occasion, the same gentleman submitted a specimen of earthenware found near a shell-mound at Port Alfred for identification by natives in Grahamstown. The reply was: "The Gonaquas made these pots, baas." I have examined the pottery in question, and find it to be typical strandlooper as described by Dr. Péringuey.

If we assume, as most writers do, that the earliest inhabitants of this region were Bushmen, with littoral representatives akin to the western strandloopers, and that the Hottentots* came as invaders from the west (or from the north-west), it may well be that considerable sections of Bushman or true strandlooper stock became incorporated in the Gonaqua tribes at an early date. This would explain the close

* It is generally believed that Hottentots are comparatively recent immigrants in South Africa. Theal tells us that they preceded the earliest Portuguese explorers by not more than two or three centuries. This assertion is based on Koranna tradition collected at Pniel by the Rev. Kallenberg, but is not adequately supported from other Hottentot sources, nor even by the Koranna tradition recorded by Arbousset. The estimate should not be taken too seriously, although no doubt the pastoral Hottentots were the latest of successive waves of yellow-skinned invaders.

resemblance between Gonaqua pottery and that from the Western Province referred to strandloopers by Dr. Péringuey. But the evidence of the pottery must not be pressed too far, as it seems possible that such pots were also made by the typical pastoral Hottentots of the Western Province.

Bushmen.

In the earliest days of South African history most of the mountainous districts of South Africa were occupied by Bushmen. At the Cape, in Van Riebeek's time, they were known as Souqua (Sanqua) or mountain Hottentots, "a very wild people without houses or cattle"; and others called Obiqua earned a bad reputation amongst the pastoral Hottentots as cattle thieves and murderers. However, they were few in numbers near the Cape, and were not a menace to the settlement, the adjacent territory being held by Hottentot tribes. On Kolben's map, Sonquas Nalie and Ubiquas Nalie are represented far inland near the Rio de Infantes. They have also been known from much earlier times under their Bantu name Buhia or Batoa,* and thus are represented on Pigafetta's map (1591) occupying territory near Monomotapa. Under such names they have always figured in history as inland or mountain tribes, maintaining continual warfare with the pastoral peoples of the coast belt.

Although rock-paintings occur in and around Grahamstown, I have failed to find documentary evidence for the former existence of Bushmen there. They probably retired northwards long before the arrival of the European settlers in the pastoral districts of the Eastern Province, or it may be, as their name suggests, that the Damasonqua Hottentots contained Bushman admixture and that our rock-paintings may be referred to this tribe. Thus might be explained the fact that several of the paintings have a modern appearance, both in freshness of colour and in the quasi-European dress of certain human figures there represented.

The Bushmen were described by Le Vaillant in the following terms:—"A collection of Mulattos, Negroes, Bastard whites, and sometimes Hottentots; mongrels of all kinds and every shade of colour, resembling each other only in treachery and villainy." This was probably the ordinary meaning of the term. Le Vaillant also realised a more modern conception of a Bushman race, for he says:—

> "Under the name of Boshis-men are likewise confounded a nation different from the Hottentots, who, though they use the same kind of clucking, have a particular kind of pronunciation and

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* The Suto rendering is Baroa, and, according to Rev. I. Torrends, S.J., in his "Grammar of the South African Bantu Languages," this is no other than the modern form of Parua-im mentioned in the Old Testament: "and the gold was the gold of Parvaim" (Parua-im), 2 Chron., iii, 6. This seems a reasonable suggestion in view of the fact that the ancient gold mines of Mashonaland were in the land of the Bushmen. But biblical expositors have offered other suggestions, one of them even connecting the word with Peru in the New World!

terms very different from the rest. In some cantons these are called Chinese Hottentots, because their complexion resembles the Chinese seen at the Cape. Like them, too, they are of a middling stature."

He describes them as "a particular race of Hottentots," and their former home Camdeboo, the Bockeveld and the Roggeveld, and at that time ranging the vast space between Caffraria and the country of the Great Namaquais. From Sparrman's account it is clear that Bushmen of this type were originally numerous between the two Fish Rivers. Writing from Agter Bruintjes Hoogte, he says:—

"Not far from here lived the Chinese or Snese Hottentots, whose chief resort is on each side of the two Fish Rivers. Many of them had been good serviceable slaves."

He saw remains of their habitations between the two Fish Rivers.

"Another and more considerable part of this yellow-skinned nation is dispersed over a tract of country eleven days' journey in breadth, and situated more to the north than to the north-east of the Fish Rivers, near a river called Zomo (Tsomo), where some of them are said to be occupied in the grazing and rearing of cattle. The rivers running through the country of the Snese-Hottentots are t'Kamsi-t kay (White kei), t'Nu-t'. kai (Black Kei), Little Zomo and Great Zomo."

In the Sneeuwbergen, north of Camdeboo, the Bushmen were still very numerous towards the end of the eighteenth century. Barrow tells us that the Bosjesmans, known in the colony as Chinese or Cineeze Hottentots, are "amongst the ugliest of human beings." The horde or kraal consisted of five-and-twenty huts, each made of a small grass mat bent into a semicircle and fastened down between two sticks, open before, but closed behind with a second mat; they were about three feet high and four feet wide. Their domestic arts were reduced to a minimum. They had woven grass mats and fish baskets, but apparently no pottery, and Burchell also made no mention of earthenware utensils in his account of Bushmen. This seems remarkable in view of the fact that coarse pottery is so frequently found in "Bushman" caves. However, we learn from Arbousset that the Bushwomen of Basutoland did make pottery, and the available evidence seems to indicate that whilst the potter's art was unknown to the primitive inland Bushmen, they readily adopted it under Hottentot or Kaffir influence (*vide* Miss M. Wilman).

Kaffirs.

During the seventeenth century, the Kaffirs had not advanced so far west of the Great Fish River. The Xosas* were known to be in the neighbourhood of East London by the year 1686, and in 1702 a band of Kaffirs had actually

* For a good account of Bantu migrations, see a paper by W. Hammond Tooke on the "Geographical Distribution of Hottentot and Bantu in South Africa" (Records, Albany Museum, vol. ii, 1913).

penetrated the Colony as far as the Boschberg (Somerset East). Before 1750 the bulk of the Xosas had crossed the Kei, and by 1775 the whole tribe was west of that river. It was not until the second half of the eighteenth century that the Xosas crossed the Great Fish River in numbers. They overran the districts of Albany and Somerset East, and some went so far west as the Long Kloof. C. P. Thunberg, in 1772, saw them in numbers at the Camtours River, where Hottentots and Caffres lived promiscuously. Then commenced a series of Kaffir wars, by which the Kaffirs were ultimately driven back beyond the Great Fish River.

Le Vaillant says of them:

> "The Caffres are taller than the Hottentots of the Colonies, or even than the Gonaquais, though they greatly resemble the latter, but are more robust and possess a greater degree of pride and courage. The features of the Caffres are likewise more agreeable, none of their faces contracting towards the bottom, nor do the cheekbones of these people project in the uncouth manner of the Hottentots."

Their huts were bigger and better made than those of the Hottentots. Their weapons were assegais and knobkerries, and in war they carried shields of buffalo hide. He saw them making assegais, using stone hammers and bellows of a most primitive type—quite different from the double bellows now employed by the Bantu blacksmiths, although according to Lichstenstein the Xosas did use the double bellows. They could not extract iron from the ore. They were agriculturists having fields of Kaffir corn. Chieftainship was hereditary, the eldest son succeeding.

In all probability the Kaffir tribes east of the Kei River all contain a Hottentot element, despite the contempt commonly manifested by Xosa Kaffirs towards the Hottentots. According to Theal, one Hottentot tribe, the Damaqua, became completely incorporated with the Amantinde Kaffirs. In Sparrman's time the Damaqua of Van Staadens River "seemed to have a greater affinity to the Caffres than the Gonaqua had," and since that date the Damaqua tribe has had no separate existence. Another powerful tribe of Kaffirs, the Amagqunukwebe, now living near Kingwilliamstown, but a century ago notorious as invaders of the Zuurveld, took origin in a little colony of Hottentots which sheltered fugitive Kaffirs to such an extent that the Hottentot element became quite submerged. Their name is just the Kaffir form of the Hottentot word Gonaqua (*see* Theal's "History of South Africa before 1795," vol. iii, p. 79).

To-day, however, the Hottentot element is not noticeable in their features, or not more so than in other Kaffir tribes of this region. For more than a century they have been regarded as Kaffirs of unmixed origin. But seeing that all the Bantu tribes of South Africa show Hottentot or Bushman influence in the clicks of their speech, it may be that an aboriginal strain pervades them all.

Skulls of Eastern Province "Strandloopers."

In the Albany Museum are a few human skulls belonging to the aboriginals of the Eastern Province. The most remarkable is one unearthed, along with the incomplete skeleton, from an old burial place on the golf links, Port Alfred. I am informed that the corpse had been buried in foetal position, and that a definite chamber had been excavated for its reception in the calcareous sandstone. The individual was an elderly man, and from the nature of his teeth, the crowns of which are worn quite flat, it may perhaps be inferred that his food had been mixed with sand, and thus he was probably of "strandlooping" habits. However, the skull (Pl. XXXI) in some respects is very different from that of a strandlooper as defined by Shrubsall,* or from the Bushman as described by Sir William Turner.† Moreover, it is much larger than the ordinary Bush skull.

It is prognathous subnasally; the forehead is retreating as well as narrow, frontal eminences indistinct; the occiput presents a conspicuous protuberance, and the skull is long. Seen from above, the parietal eminences are not prominent, though the breadth there is much greater than more anteriorly, and in this respect it probably differs from Kaffir skulls of unmixed origin—in norma occipitalis, the pentagon is not so well defined as in Bushman skulls, and its sides are not flattened. The brow ridges are well developed; on the right side is a supra-orbital foramen, on the left side a notch; orbits rectangular, with the long axes oblique. The face is very broad, the cheek-bones strongly projecting. The lower margin of the nasal orifice is rounded off and indistinct. Nasal bones are broken, but evidently small and obliquely inclined, the nose being flattened greatly but not to an extreme extent, and the maxillary dces not encroach on the bridge. Frontal and squamosal are separated, temporal fossae ill-filled. There is a very strongly developed temporal ridge; the vertex is not flattened. The mastoid process is moderately large, and the supra-mastoid groove is shallow and broad.

The mandible (Pl. XXXII) is a most characteristic feature of this specimen. The ascending ramus is greatly elongated in the antero-posterior direction, but is short in a vertical direction. This character, as first pointed out by Professor Rolleston,‡ is one which at once serves to distinguish Bush from Kaffir mandibles, and in the specimen before us witnesses definitely to a non-Kaffir element. In Bush mandibles the ascending ramus is always comparatively broad and low as compared with those of Kaffirs.

The least breadth of the ramus (46 mm.) far exceeds that of any specimen recorded from South Africa. In six Bushmen skulls recorded by Turner, the range is only

* "Annals of South African Museum," vols. v and viii.

† Report of H.M.S. "Challenger," "Zoology," vol. x.

‡ In "Matabeland and Victoria Falls," by F. Oates.

30·5-35 mm., and Shrubsall's series of eight Bushmen and strandloopers ranged from 32-37 mm. The fossil Mauer jaw has a least breadth of 50-52 mm., whilst that of average Germans is said to be only 27 or 28 mm. The sigmoid notch is also remarkably shallow in this specimen, with very low coronoid process, and another very noticeable feature is the strongly everted angle, which again is Bush character in exaggerated form. The chin is quite distinct, and the lower jaw projects in front beyond the upper. The mandible as a whole is slender and light.

The measurements are as follows:—

- Cranial capacity, 1415 c.c.
- Basi-bregmatic height, 130·5 mm.
- Maximum breadth, 139 mm.
- Bi-maxillary breadth, 108 mm.
- Maximum glabello-occipital length, 192 mm.
- Bizygomatic breadth, 144 mm. (This is noticeably great.)
- Naso-alveolar height, 69 (circa).
- Orbital height, 32 mm.
- Orbital breadth, 42 mm.
- Basi-alveolar length, 108 (circa).
- Basi-nasal length, 108·5 mm.
- Height of ramus of mandible, 44 mm.
- Bi-condyloid breadth, 122 mm.

Thus, in terms of physical anthropology, it is dolichocephalic (72·4), chamaecephalic (68), mesognathous (99·5), metriocephalic (94), chamaeprosopic (48) and microseme (76).

On a flat table, this skull rests posteriorly on the mastoids, the cerebellar part of the occipital bone and the condyle being well raised up.

I cannot pretend to assign this solitary specimen with certainty to his proper place in the system. There is without doubt a strong strain of the San race, but if the pure type of that race is the strandlooper described by Dr. Shrubsall, some other elements must be intermingled, judging from such characters as the length and shape of the skull, the weak forehead, and the size of the mastoids. It agrees with typical strandloopers rather than with Hottentots—as understood by Shrubsall—in the chamaecephalic skull, the broad rectangular orbits, and the very broad chamaeprosopic face.

We have no other example quite like the above, but considerably resembling it in the shape of the cranium is a badly broken skull from the sand-hills, Port Alfred. The length is 203 mm. There is the same occipital protuberance; parietal eminences fairly distinct; brow ridges moderate, temporal ridges weak; nasals considerably flattened; face and eye-sockets not so broad, and cheek bones not so strongly projecting as in the above example, and very little subnasal prognathism; a sharp rima borders the nasal opening, which is not broad. The mandible is lacking, unfortunately. Partly owing to the bulging occiput, this skull is longer than any in

our collection that can be referred with certainty to recent Kaffirs, but resembles some of them in facial characters. It is possibly a Kaffir-Hottentot-Bush hybrid, the non-Bush elements predominant.

Another specimen from the sand-hills at Kleinemonde, consisting of brain case only, is still longer, 204 mm. It is, however, narrow as well as long, and has no parietal eminences, nor is there a well-marked occipital protuberance.

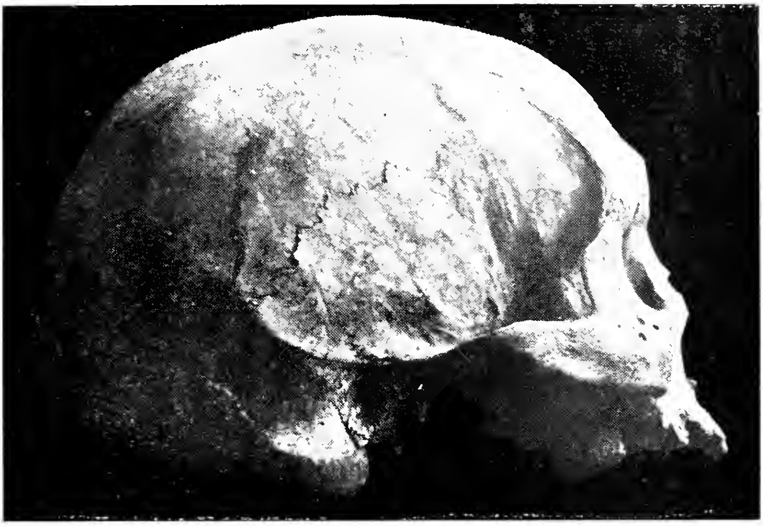
In addition to these large- and long-headed strandloopers, the Albany Museum has one specimen from the sand-hills, Port Alfred, which seems typically strandlooper so far as can be judged from the size and shape of the cranium, its face and mandible being lacking. Moreover, this specimen is noteworthy in possessing a fronto-squamous suture on both sides. Yet amongst a few complete Hottentot or Bush skulls from the same locality, not one agrees wholly with the western strandlooper type. A skeleton from Port Alfred (exhibited as that of a Bushwoman) is distinctly prognathous (103·2), the teeth large and crowded, eye-sockets comparatively rounded, and the lower margin of the nasal aperture well rounded off. Another female specimen, from the Port Alfred golf links, though not so prognathous (100), has the ascending ramus of the mandible rather high and the sigmoid notch deep.

A strandlooper skull from East London, unearthed during excavations made in the construction of a patent slip in 1896, is tapeinocephalic and chamaecephalic, but very prognathous (104), and the nose is not compressed, though the aperture is fairly broad. This specimen is interesting in possessing a perfect suture across the right malar bone, as also found in Bushmen by Prof. Rolleston. The sigmoid curve of the mandible is comparatively shallow, and the coronary process low, but the condyloid process is high. The mastoids are small, and the skull rests behind only on the cerebellar part of the occipital.

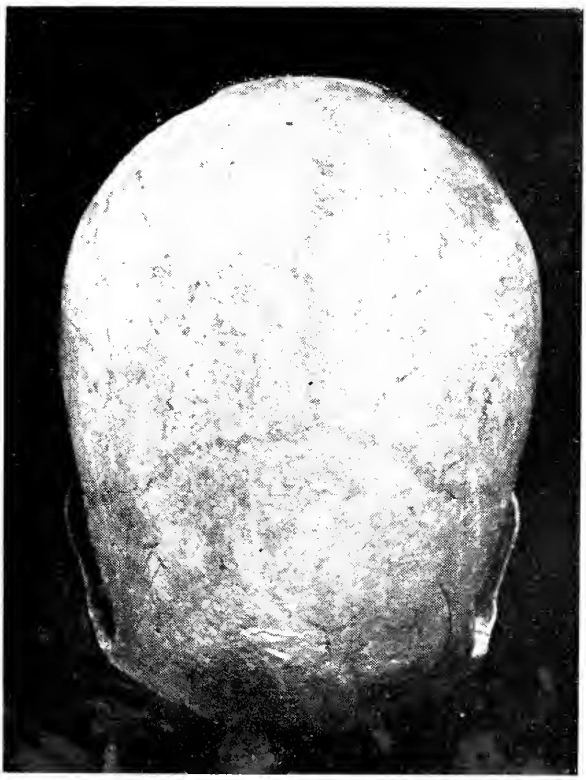
Amongst the various eastern strandlooper skulls in the Albany Museum, the one which conforms best to the western strandlooper type came from Port Elizabeth, being unearthed during Harbour Board excavations. This is chamaecephalic and almost orthognathous, the index being about 98. Yet the mastoids are relatively well developed, and the skull rests behind on these and the cerebellar part of the occipital: it is, moreover, tapeinocephalic (88).

Knowing absolutely nothing concerning the antiquity of any of these specimens, the available data is much too small to warrant a connected account of the eastern strandloopers. Whether the short-headed orthognathous men of the Western Province ever lived here we do not know.

The evidence of the skulls seems to harmonise with that of history in witnessing to the former occurrence along our coast of bastard tribes containing Bush, Hottentot and Kaffir elements, the skulls examined constituting a very hetero-

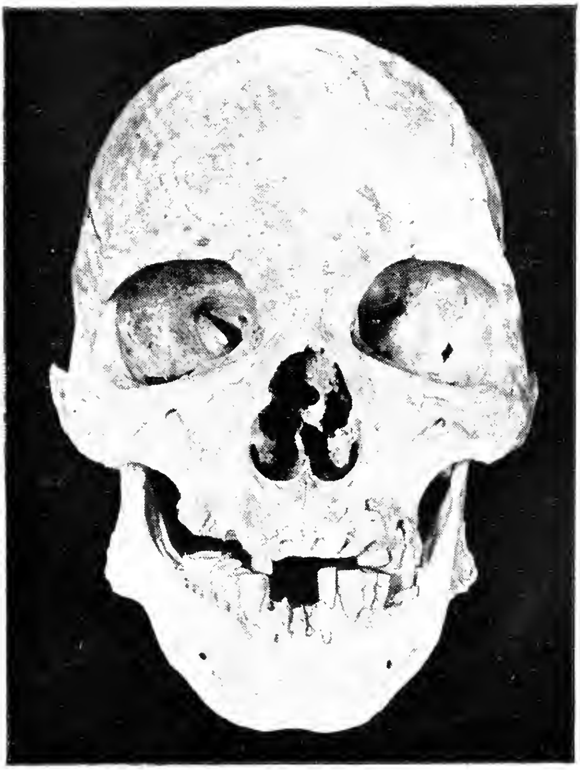


"STRANDLOOPER" SKULL FROM PORT ALFRED.



"STRANDLOOPER" SKULL FROM
PORT ALFRED.

MANDIBLE OF PORT ALFRED "STRANDLOOPER."
(Note that the hole pierced in the condyle is artificial.)



"STRANDLOOPER" SKULL FROM
PORT ALFRED.

geneous lot. It is very improbable, however, that such skulls merely represent various grades of intermixture between the true strandloopers and the Kaffirs.

In several respects the skull first mentioned resembles those described by Professor Elliot Smith under the name of Proto-Egyptian.* This authority lays stress on the fact that the typical pre-dynastic mandible had a very short but broad ramus, and shallow sigmoid notch, thus differing greatly from the mandibles of the aliens who entered Egypt under dynastic times. Moreover, the Proto-Egyptian had a long, narrow skull, with the occiput bulged out into a marked prominence of the back of the head. On the other hand, the face was narrow, thus differing from the Bush-Hottentot type. This seems significant in view of the fact that various authorities on linguistic grounds have noted a relationship between the Hottentots and various pastoral Hamitic tribes of North-East Africa, one of those tribes, the Gallas, even making use of clicks. It may be that the source of the bulging occiput, conspicuously developed in the above-mentioned specimen, and represented in various Bushman skulls according to Sir William Turner, is to be traced to the earliest Hottentots, who centuries ago left the cradle of their race in North-East Africa, and, along with herds of long-horned cattle and flocks of fat-tailed sheep, slowly made their way to the pastures of the south.†

* "The Ancient Egyptians," by G. Elliot Smith.

† On the relationship of South African tribes to those of tropical and North Africa, the reader may find useful information in Sir Harry Johnston's paper, "A Survey of the Ethnography of Africa" (Journal. Roy. Anthrop. Instit., vol. 43, 1913). His account of strandloopers, though said to be based on Shrubsall's conclusions, seems to me somewhat strained.

THE ECONOMIC VALUE OF A STUDY OF THE NEMATODES, WITH REMARKS ON THE LIFE HISTORY OF *HETERODERA* IN SOUTH AFRICA.

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Read July 15, 1920.

The numerous difficulties associated with the study of the Nematodes, or "thread-worms," has not tended to encourage investigation on this important group, with the result that at the present time probably rather less is known about the group than of any other of comparable magnitude. Many problems of the biology even of some of the better known members of the group remain unsettled, while the existing knowledge of the affinities of the group as a whole with other groups of the animal kingdom leaves much to be desired. Numerically, the Nematodes are a very large group, and the variety of form that they exhibit is said to rival that of the insects. Correlated with this great variety in form is found an equally large variety in habits, ranging from the free-living Anguillulidae, and progressing by almost imperceptible gradations until the completely parasitic existence, such as is found in many of the members of the Filariidae and Trichinellidae, is assumed. Some of the members of the group possess a remarkable plasticity in habit, and are able to adapt themselves to most profound change in habitat and other surrounding influences, demonstrating the phenomenon of incipient parasitism clearly. As an example, *Anguillula putrefaciens*, normally found in decaying onions, is recorded from the stomach of a man suffering from nausea. Again, *Rhabditis pellio*, a free-living inhabitant of damp soil, has been described as causing vaginal infections, and has furthermore been found capable of infecting rats when experimentally introduced.

Dr. N. A. Cobb, an eminent authority on free-living and plant-parasitising Nematodes, in reviewing the vastness of the numbers of the Nematodes, the enormous variety of their forms and the important relationships that they bear to mankind, states: "The Nematodes offer an exceptional field of study, and probably constitute almost the last great organic group worthy of a separate branch of biological science comparable with Entomology." For this new branch of science the name "Nematology" is proposed by Cobb, although the term "Helminthology" is well established and includes the study of these forms.

In order to point out more prominently the rôle played by the Nematodes as parasites of great economic importance, the following list has been prepared. It is hoped that it may help to supply a want felt by zoologists in South Africa for a general list of Nematode parasites. For the sake of convenience the subject has been treated under three main heads, according to the hosts affected—agricultural crops, domestic animals, and man.

Some remarks are also appended (Section IV.) on the author's researches on the life-history of *Heterodera* in South Africa.

I.—Some Nematodes of Agricultural Importance.

Almost without exception, the Nematodes, or "eel-worms," that parasitise the tissues of plants, belong to the family Anguillulidae, while the genera mainly concerned are *Aphelenchus, Heterodera* and *Tylenchus*. Very few plants are totally immune to the ravages of one or other species of these genera, and the tissues infested, although often localised, may vary from the roots to parts of the stem, vascular tissues of the leaves, etc. The genera *Aphelenchus*, *Heterodera* and *Tylenchus* are characterised by the presence of a buccal spear, a chitinous organ, which enables them to pierce the root tissues in order to carry on their parasitic life effectively.

Of special importance are the following:—

Aphelenchus armerodus.—A parasite on violet buds.

A. cocophilus.—The cause of serious maladies in the coco-nut palms in the West Indies.

A. pyri.—A remarkable parasite which causes pears to decay.

A. fragaria.—A destructive strawberry parasite.

Heterodera schachtii.—It was probably due to the ravages of this organism that the attention of observers such as Schacht, in 1859, and Schmidt, in 1871, was first drawn to the importance of Nematodes as serious plant pests. *H. schachtii* was demonstrated to be the direct cause of "sugar beet sickness" in Germany and many other European countries. The same parasite has since been found to form galls, or root swellings, on maize, barley, rye, oats, winter and spring wheat. In hops it causes the disease known as "nettle-head."

Heterodera radicicola.—This is without doubt the most troublesome of Nematode plant parasites. The roots of the plant are attacked by the larval worms, and large disfiguring galls, or root-knots, are produced, which usually interfere with and upset the vital functions of the roots. More than 500 plants, the majority of which are of economic value, are attacked by this parasite. Among the more important host plants are: Most orchard trees, such as peach, apple, grape, fig,

"lady-finger" banana, etc.; many ornamental shrubs and flowers, such as carnation, rose, violet, snapdragon, etc.; numerous vegetable crops, such as carrots, turnips, cabbages, potatoes, tomatoes; cereals, such as oats, wheat (*Triticum aestivum*), and perhaps maize, and other plants such as tea, coffee, tobacco, cotton, flax, okra, lucerne, rubber tree, elm, sugar cane, together with many others, are more or less seriously damaged.

Remarks on the life-history of *Heterodera*, as investigated by me in South Africa, will be found on page 330.

Tylenchus acutocaudatus.—The causative agent of a disease in banana groves recently reported from the vicinity of Alexandria. The same parasite has also been found in coffee trees.

T. biformis.—A parasite of the roots of sugar cane. Reported from Hawaii.

T. devastatrix, syn.: *T. dipsaci*, *T. scandens.*—This is the common stem eel-worm widely distributed over Europe, Australia and other countries. It is responsible for much damage to onions, narcissus bulbs and buckwheat. It produces stem rot in clover. In South Africa, although only of recent introduction, it has become widespread, and makes the cultivation of lucerne almost impossible in many districts. When once introduced, its eradication has, so far, proved impossible.

T. oryzae.—Infests rice plants in Java (? = *T. angusta*, a rice plant parasite of Bengal.)

T. mahoganii.—A parasitic Nematode connected with a disease in the mahogany tree.

T. penetrans.—First described from the roots of violets in New York (1911). It has since been recorded from potatoes, cotton, and camphor tree roots.

T. semipenetrans.—A parasite of the roots of citrus plants in California, Algeria, Australia, etc.

T. similis.—A parasite described by Cobb (1915), in the roots of sugar cane and banana.

T. sacchari.—The probable cause of a sugar cane disease known as "sereh."

T. tritici.—Causes a pernicious disease of wheat, producing "ear-cockles." Widespread in Europe and America.

Besides the direct damage inflicted by Nematodes, as plant parasites, a much wider rôle has been assigned to them in the production of disease. Not infrequently their presence in the roots permits the invasion of malignant bacteria and other pathogenic organisms, which are the primary causes of disease. An example of a bacterial disease of cotton roots, made possible by the ravages of Nematodes, is found in the "black-root" disease in America.

II.—Nematodes in Domesticated Animals.

All genera of vertebrates are said to harbour one or more species of Nematode parasites. Often, however, the number of parasites that are peculiar to certain hosts, such as sheep, oxen, horses and dogs, is quite formidable, and the losses incurred as a result of their activities are very considerable.

The study of the Nematode parasites of domesticated animals, their life-histories and methods of control, has already attained considerable proportions, as shown by the literature, but much still remains to be done. The taxonomy is difficult. Only a rough classification, sufficient to indicate the general position of some of the principal parasites, is used here.

The following is a list of some of the chief Nematodes found in domesticated animals:—

ANGIOSTOMIDAE.

Strongyloides papillosus (longus) is parasitic in the small intestine of sheep, pigs and rabbits.

Probstmayria vivipara is found in the large intestine of the horse and donkey.

GNATHOSTOMIDAE.

Gnathostoma hispidum is found in the stomach of the pig and ox.

FILARIIDAE.

Filaria irritans is the cause of "summer sores" in horses in Australia.

F. clava occurs in the peri-tracheal connective tissue of the pigeon.

F. spicularia occurs in the sub-pleural and sub-peritoneal tissue of the ostrich.

F. gallinarum occurs in the intestine of the fowl.

F. (Dirofilaria) immitis is found in the heart of dogs.

F. (Setaria) equina occurs in the peritoneal cavity of horses.

Thelazia—*T. lacrymalis* and other species are parasitic in the lachrymal glands, eyeball and under eyelids in many mammals, *e.g.*, horse, ox, buffalo, camel, dog. A species was recently found in the eye of an ox in Johannesburg.

Onchocerca reticulata has been found in the ligaments of the fore-limbs of horses; *O. cervicalis* in horses; *O. lienalis* in cattle, and *O. gibsoni* occurs in the subcutaneous ("wormy") nodules in cattle in Queensland.

Besides being the host of the adult worms, many larval Nematodes (*Microfilariae*) are found in the blood of cattle in India and Africa.

Spiroptera megastoma and *S. microstoma* occur in the stomach of the horse and donkey; *S. sanguinolenta* in the dog; *S. pectinifera* in gizzard of fowl; *S. strongylina* in stomach of pig.

Gongylonema scutatum, parasitic in the œsophagus of sheep, cattle, goats and horses; *G. verrucosum* in rumen of sheep and cattle; *G. ingluvicola*, in the crop of poultry.

Dispharagus.—Many species occur in the digestive tracts of fowls.

Oxyspirura.—Several species occur in the nictitating membrane of birds.

Simondsia paradoxa occurs in the stomach of the pig.

TRICHOTRACHELIDAE.

Trichosomum.—Numerous species parasitic in the bladder of the dog and cat, and in the gut of poultry and game birds.

Trichinella spiralis.—The larval stage is passed in the gut and muscles of various domestic animals, *e.g.*, pig.

Trichuris, syn. *Trichocephalus.*—Numerous species known popularly as "whip-worms" are found in the large intestine, especially the caecum, of domestic animals, *e.g.*, *T. ovis* (*affinis*) in cattle, sheep and goats; *T. crenatus* (*suilla*) in pigs.

EUSTRONGYLIDAE.

Eustrongylus visceralis occurs in the pelvis of the kidney of the dog, horse, ox, pig, etc.

STRONGYLIDAE.

Metastrongylus apri, in the trachea and bronchi of the pig and sheep; also *M. brevivaginatus* in the pig.

Dictyocaulus arnfieldi occurs in the bronchi of horses; *D. filaria*, occurring in the bronchial tubes of lambs and sheep, is said to cause "husk" or "hoose"; *D. micrurus*, in deer; *D. viviparus* in cattle.

Synthetocaulus rufescens and other species in pulmonary tissues of sheep and goats.

Haemostrongylus vasorum, in the heart of the dog.

Haemonchus contortus.—The "wire-worm" of sheep, goats and cattle, occurring in the abomasum.

Graphidium strigosum, in the stomach of rabbits.

Nematodirus filicollis, in the small intestine of sheep; *N. digitatus* in cattle.

Trichostrongylus retortaeformis in the small intestine of rabbits; *T. extenuatus* in the small intestine of sheep and cattle; *T. axei* in horses; *T. vitrinus* and *T. probolurus* in sheep, camel (also in man); *T. instabilis* in sheep and goats; *T. pergracilis* in grouse; *T. douglasi* in the proventriculus of ostriches.

Ostertagia ostertagi is found in the abomasum of cattle and sheep; *O. circumcincta* and *O. trifurcata* in sheep.

Cooperia curticei occurs in the small intestine of sheep and cattle; *C. oncophora* in cattle.

Oesophagostomum radiatum is found in the intestine of cattle; *Oe. columbianum* in sheep and cattle; *Oe. venulosum* in sheep and goats; *Oe. dentatum* in pigs.

Chabertia ovina is found in the large intestine of sheep and goats.

Agriostomum vryburgi occurs in the small intestine of certain cattle.

Ancylostoma caninum, in the small intestine of dogs and cats.

Characostomum longemucronatum, in small intestine of pig.

Bunostomum trigonocephalum, in small intestine of sheep and goats; *B. phlebotomum* in cattle.

Gaigeria pachyscelis, in the intestine of sheep and cattle.

Gyalocephalus capitatus is found in the large intestine of mules.

Triodontophorus minor and *T. serratus*, in the large intestine of donkeys.

Cylicostomum.—The following species have been found in the large intestine of the horse and donkey:—*C. alveatum, auriculatum, bicoronatum, calicatum, catinatum, coronatum, elongatum, labiatum, labratum, nassatum, poculatum, radiatum* and *tetracanthum*.

Oesophagodontus robustus, in the caecum of the horse and mule.

Several species, occurring in the digestive tracts of cattle, sheep and goats, formerly referred to the genus *Strongylus*, are now distributed in other genera. The nomenclature of the Strongylidae is still difficult and confused. Several sub-families, such as Metastrongylinae, Trichostrongylinae and Strongylinae have been founded. Further investigation is needed.

From the large intestine, especially the caecum of the horse, the following species of *Strongylus* have been recorded: *S. equinus, edentatus* and *vulgaris*.

Syngamus trachealis and *S. bronchialis* occur in the trachea and bronchi of fowls, pheasants, turkeys, peacocks and geese, causing "gapes"; *S. laryngeus* in cattle; *S. nasicola* in goats.

Stephanurus dentatus has been found in the adipose tissue around the kidney of the pig.

ASCARIDAE.

Ascaris suum (*suilla*) occurs in the small intestine of pigs; *A. ovis* in sheep; *A. vitulorum* in cattle; *A. megalocephala* in horses; *A. crassa* in ducks; *A. lonchoptera* in the elephant.

Belascaris marginata is found in the intestine of dogs; *B. mystax* (=*B. cati*) in cats.

Toxascaris limbata occurs in the intestine of the dog and also accidentally in man.

Heterakis perspicillum is found in the intestine of fowls, turkeys and guinea-fowls; *H. vesicularis* in poultry and game birds; *H. columbae* in pigeons.

Oxyurus curvula has been found in the intestine of the horse, mule and donkey; *O. compar* in cats; *O. ambigua* in rabbits.

III.—Some Nematodes Parasitic in Man.

The Nematode parasite fauna of man is very large and very diverse in character, consisting of members of nearly all the genera of the group. Some of the examples recorded may be regarded as only "accidental" or occasional parasites, but the large majority depend upon man for their normal host, in whom they pass their larval development or adult parasitic phase.

The following list includes only some of the most important parasites, no attempt being made to exhaust the record of human Nematode parasites:—

ANGUILLULIDAE.

Rhabditis (Leptodera) pellio, from the vagina; *R. niellyi* has been found in skin papules in a child.

Anguillula aceti, the "vinegar eel-worm," has been recorded from the human bladder and from vomits. *A. putrefaciens* has also been found in vomits.

ANGIOSTOMIDAE.

Strongyloides stercoralis.—The causal agent of a type of diarrhoea first described from soldiers in Cochin China.

GNATHOSTOMIDAE.

Gnathostoma siamense (?= *G. spinigerum*).—Recorded from the skin of a Siamese, where it produces nodules.

PHYSALOPTERIDAE.

Physaloptera mordens and *P. caucasia*.—Parasitic in stomach and small intestine.

FILARIIDAE.

Filaria bancrofti.—Adults found in lymphatic system. There is a microfilarial stage, *Mf. nocturna*, found in the blood. Causes elephantiasis, chyluria and lymphangitis in tropical countries, *e.g.*, China, India, West Indies and Queensland. Transmitted by mosquitoes.

F. demarquayi.—Adult females found in the mesentery, larvae in the blood. Distribution: West Indies, British Guiana.

F. taniguchi.—Parasitic in the lymphatic glands. Japan.

Acanthocheilonema perstans.—Adult forms found at base of the mesentery, especially around the pancreas. Larval form, *Mf. perstans*, in blood. Tropical Africa, British Guiana.

Loa loa.—Found in various superficial connective tissues, such as those of the conjunctiva, eyelid and other parts, giving rise to Calabar swellings. Larval stage is *Mf. diurna* in the blood. Transmitted by *Chrysops* fly. Distribution: West Africa.

Onchocerca volvulus.—Found in subcutaneous tumours. Occurs in West Africa.

DRACUNCULIDAE.

Dracunculus medinensis ("Guinea-worm").—Inhabits the subcutaneous connective tissue, and causes superficial ulcers on the legs and feet. Larvae transmitted by *Cyclops*, a fresh-water Crustacean. Endemic in Tropical Africa, South America, Arabia, India.

DIROFILARIIDAE.

Dirofilaria magalhaesi.—Found post-mortem in the heart. Reported from Rio de Janeiro.

TRICHINELLIDAE.

Trichinella spiralis.—In the adult stage, this parasite normally inhabits the small intestine of the pig, wild boar, rat and man. The females are viviparous, and the larvae, deposited in the lymph spaces of the intestines, are carried by the lymphatic and blood streams to the muscular system in which they eventually encyst. The encapsuled larvae, which may occur in the muscles of man or pig, are liberated, and arrive at maturity when introduced with food into another host. This parasite, when present in large numbers, may be fatal to man. Distribution almost universal.

Trichuris trichiura (*Trichocephalus dispar* of earlier writers).—The common "whip-worm" of man. It inhabits the caecum, vermiform appendix and colon, and may cause anaemia and disturbances of the nervous system. Distribution is apparently world-wide.

DIOCTOPHYMIDAE.

Dioctophyme renale.—This parasite is usually found in the pelvis of the kidney of the dog, wolf, fox and horse, but is occasionally found in man.

STRONGYLIDAE.

Trichostrongylus instabilis and *T. vitrinus* are occasionally found in man.

Ternidens deminutus has been recorded from the large intestine of natives in Nyasaland.

Oesophagostomum brumpti was found in tumours of the caecum and colon of an East African native.

Oesophagostomum stephanostomum has been recorded from submucosal haemorrhagic cysts in the human intestine.

Ancylostoma duodenale.—The "miner's-worm," or "hook-worm." Inhabits the small intestine, chiefly the jejunum, and causes pernicious anaemia. Its occurrence is world-wide.

A. ceylanicum and *A. braziliense* are allied forms.

Necator americanus.—This parasite was formerly confused with *Ancylostoma duodenale*, and its action is similar. Its distribution is also wide.

ASCARIDAE.

Ascaris lumbricoides.—This parasite, popularly known as the "round" worm, is one of the most frequent parasites of man, in the intestines of whom they often occur in large numbers. It is universal in its distribution.

OXYURIDAE.

Oxyuris vermicularis.—The common "seat-worm," inhabits the large intestine. The young forms are frequently found in the vermiform appendix, and latterly a rôle has been suggested or assigned to them in the cause of appendicitis.

IV.—Some Remarks on the Life-History of *Heterodera* in South Africa.

The life-history of *Heterodera radicicola* may perhaps be treated more extensively, as it merits observation both on account of the peculiarities of its development and because of the practical interest that must be attached to one of the most destructive and, at the same time, one of the most uncontrollable of plant parasites. The genus has been the subject of investigation by the author of this paper for a considerable time past, and the following is a brief *résumé* of its development, together with some observations on the biology of the parasite, which, it is hoped, may help to elucidate the numerous difficulties and problems that have arisen.

On cutting open the "gall" or "knot" of a root infested with *Heterodera*, a variable number of pearly white pear-shaped "cysts" about 0·7 mm. in length are visible. These "cysts" prove to be the adult gravid females of the parasite, which have become swollen on account of the large numbers of eggs within the body, and it is to irritation of the root tissues set up by their presence that the rapid multiplication of cells, leading eventually to the formation of root galls, is due. In the parasite, presumably *H. radicicola*, common throughout South Africa, that has been investigated, the eggs, sixty to eighty in number, undergo segmentation, and the larvae emerge from the egg cases while still within the uterus of the now defunct mother. Despite careful

observations, no ecdysis of the larval cuticle has been noted before or soon after the larva hatches from the egg. The larvae pierce their way through the uterine and body walls of the mother, and so escape into the root tissues. They do not appear to grow to any considerable extent after hatching. Morphologically, the larvae closely resemble those of the genus *Tylenchus* and *Aphelenchus*, and indeed they cannot be distinguished from these except perhaps on a basis of size, the larvae of *H. radicicola* measuring from 340 to 370 μ in length, with an average uniform breadth of 15 μ. One of the most prominent structures of their anatomy is a chitinous boring organ, the so-called spear, situated in the pharynx. By means of this structure the larva is enabled to pierce a passage out of the root into the soil, where it may lie dormant for a time, then seek out and penetrate another rootlet. But, should conditions within a root be favourable, the larva may not abandon the root in which it was hatched, but may migrate to adjacent healthy tissues and there undergo sexual differentiation. At any rate, sexual differentiation does not take place outside the tissues of a root. The future sex of the larva cannot be ascertained prior to the commencement of the developmental metamorphosis. Evidence has recently been acquired by the author which indicates that the larva in the soil undergoes an ecdysis. However, the old skin is not cast, but adheres to the new larval cuticle, giving it a double appearance. Sexual differentiation, which is accompanied by a profound change in shape and alteration of internal organs, commences soon after the larva has reached the vascular tissues of the root and has commenced to absorb nourishment. Both sexes of the parasite swell to a considerable extent, so altering their primitive worm-like shape. Rudiments of reproductive organs appear at a comparatively early stage.

Within the swollen female larva a new organisation is gradually built up by a process comparable with the formation of the imago insect within the pupa. The new organism, however, does not leave the larval encasement, but comes to occupy its entire body, assuming the rôle of the mature female with a prominent external genital aperture. This complicated process must be regarded as another ecdysis, but again the old cuticle is not discarded. Fertilisation of the female can only take place in the root tissues, because the shape of the female will not permit any movement on its part.

In the development of the adult male, the metamorphosis is even more intense than in the female. The larva, having fed and grown to a certain extent, enters into a state of complete quiescence and seems to be lifeless. But soon the presence of a new individual within the swollen dormant larva becomes manifest. This individual grows and lengthens and assumes a vermiform appearance, coiled up within the old body. Finally, this worm escapes from its larval envelope as the mature male, whose length varies from 700 μ to 2,590 μ.

In connection with the structure of the male reproductive organs, there has been much controversy. Stone and Smith, working in 1898 on *H. radicicola*, came to the conclusion that the male gonads consisted of a pair of testes. E. A. Bessey (1911), on the other hand, shares the view with Atkinson (1889) that there is only a single testis in *H. radicicola*, and states that a double testis in the male is one of the characteristics of *H. schachtii*, the sugar-beet gall-worm of Europe. So far, all efforts on the part of the author to procure specimens of *H. schachtii* parasitic in South Africa have been unsuccessful. Among the parasites prevalent in South Africa a number of adult males have been carefully examined, and in these only a single testis was evident, but in others taken from the same infested material, and so presumably of the same species, two well-developed separate testes were distinctly visible. The question consequently arises regarding the validity of two separate species of the genus *Heterodera*. It seems possible that the presence of two testes in the male may be a variation of comparatively large magnitude and of not infrequent occurrence, or it may be that two testes are developed and one atrophies or unites with its fellow at a certain stage in its development so as to appear single. Other characters stated to be peculiar to one or other species also seem to be inconstant when tested with parasites from different sources.

The biological and bionomical activities of *Heterodera* still require further investigation, in order that more successful attempts may be made to deal effectively with this pest. Problems such as the absence of the parasites from plots of ground which have been badly infested during previous seasons and have undergone no special treatment to exterminate the parasites, while ordinarily a plot of ground once infested may remain so for a large number of years, seem at present inexplicable. The explanation will probably come when more definite information on the resistant stages of the life cycle, whereby the parasite can withstand adverse climatic conditions, and whereby their distribution is affected, is acquired.

Concluding Remarks, with Special Reference to South Africa.

The value of a study of the Nematodes, both from the purely scientific view-point as well as from the position that the group occupies in relation to agriculture and disease, cannot be over-emphasised. From the "pure science" aspect, much research has already been accomplished, and the results that have been derived therefrom have been of paramount importance—as an instance, our first insight into the highly complicated process of karyokinesis, or division of the nuclear chromatin which precedes the fertilisation of the ovum, was obtained from the study of the eggs of *Ascaris*, the common round-worm of man. On the other hand, a great deal still

remains to be done in the interests of applied science. Especially do the free-living and plant parasitic genera require immediate attention, but it can only be a matter of time now before the ravages caused by "eel-worms" to the majority of our crops will compel their closer investigation. A slight conception of the enormous losses to agriculture inflicted by some of the better known Nematode plant parasites may be obtained from the following brief considerations:—

Heterodera radicicola, the parasite causing root-galls, or root-knot, is perhaps the most serious of Nematode crop pests. It infests over 500 species of plants, more than half of which number are of economic value. The actual monetary loss to farmers, due to this parasite, is inestimable. Cobb states that the losses would amount to a fortune for a nation. The parasite has a world-wide distribution, and certain localities are sometimes so badly infested as to make agriculture impossible. So far, no effective remedy, which can be satisfactorily applied on a large scale, has been devised.

H. schachtii, the European sugar-beet parasite, makes beet cultivation impossible in heavily infected fields. When only slightly infected, a loss of one-third of the entire crop is not uncommon.

Tylenchus tritici, the cause of "ear-cockles" in wheat, not only decreases and depreciates the yield of grain, but during its sojourn in the tissues seriously handicaps the growth of the plant. This Nematode disease has proved in some cases to be one of the most destructive diseases to which wheat is subject, often causing losses to the extent of 25 to 50 per cent. of the crop value.

T. devastatrix, as its name implies, is a most destructive organism, causing much damage to hyacinth bulbs, onions, buckwheat, etc. It is of comparatively recent introduction into South Africa, and already makes the cultivation of lucerne impossible in many districts. So far, its eradication has not been effected. The ravages of this Nematode on lucerne, the principal food of the ostrich, and the losses caused by *Trichostrongylus douglasi*, the Nematode parasite of ostriches, threatened at one time to ruin the industry in certain parts of the Cape Colony.

The destructive activities of Nematode parasites among stock and other domestic animals are too well known to require repetition.

As regards the Nematode parasites of man, it is often apparent that their distribution is more or less localised. South Africa is happily free from many of those pests which are prevalent in adjoining territories, but it is also seen that the physical and other conditions, which would allow of the flourishing of some of these parasites if once introduced, are often present in this country. A potential danger thus exists, and an adequate knowledge of the life-history and bionomics is necessary to prevent the introduction of the parasites. In the same way it is evident that in dealing with microscopic

parasites, such as the majority of Nematodes are, it is only when equipped with a detailed knowledge of the life and habits of a pest that we can reasonably hope to control its ravages or effect its eradication. This entails an enormous amount of study and investigation, and it is to be hoped that, when the zoological survey of the Union is begun, one of the first groups that will receive systematic attention will be the Nematodes, the study of which group, together with the economic results that are to be achieved, hold out such great inducements.

I desire to express hearty thanks to the Research Grant Board for a grant-in-aid, whereby the collection of material for the research on Heterodera was greatly facilitated.

HOTTENTOT PLACE-NAMES.

By Rev. Charles Pettman.

Read July 17, 1920.

There appears to be little question that the Hottentots came originally from Northern Africa, and that travelling southward they were subsequently cut off from the original stock by the intrusion of other nations. Driven by the pressure of these nations they found their way southward and westward to the coast of the sub-continent, and, following the coast, ultimately reached its southernmost point. Thence, still following the coast, this time eastwards, they made their way nearly, if not quite, to the borders of the present Natal, where they found their course blocked by the southward moving Bantu peoples. It was not until, perhaps, centuries later, that in remnants of broken tribes and with no small amount of mixed blood (Korannas, Griquas, Bastards), they were forced back to the vast plains of the Trans-Gariep, receding this time before the advance of the white men who had settled in the south.

How long before the advent of the Europeans the Hottentots had established themselves all round the coast of South Africa from the Kunene on the west to the proximity of Natal on the east it does not seem possible now to determine with any degree of exactness. Theal (Bleek and Lloyd "Bushman Folk-lore," 1911, pp. xxviii-xxix) argues that they could not have crossed the Kunene on their south-westward way many centuries before the white man's arrival, and bases his conclusion on

> "the fact that the dialects spoken by the tribes in Namaqualand and beyond Algoa Bay on the south-eastern coast differed so slightly that the people of one could understand the people of the other

without much difficulty, which would certainly not have been the case if they had been many centuries separated. They had no intercourse with each other, and yet towards the close of the seventeenth century an interpreter belonging to a tribe in the neighbourhood of the Cape Peninsula, when accompanying Dutch trading parties, conversed with ease with them all."

Theal's fact is important, his inference is, of course, an inference only, and would seem to estimate the period of the Hottentot advent into the sub-continent at too recent a date.

That point, however, apart, wherever they settled they would naturally give to localities and physical features of the territory which they occupied names that would be significant to themselves and appropriate to the locality or feature designated.

An opportunity occurred to me a few years back, away in the heart of Griqualand West, to take down from the mouth of a European, who had been born in Great Namaqualand and had spent the greater part of his life there, who spoke the Namaqua-Hottentot language fluently, it being practically the language of his childhood, a fairly long list of Namaqua-Hottentot place-names and their meanings. On comparing these, on my return home, with the Namaqua-Hottentot words in Krönlein's "Wortschatz der Khoi-Khoin," I found in the great majority of the names on my friend's list that his derivations and those given by Krönlein were practically the same. This seemed to indicate that to one acquainted with the Namaqua-Hottentot language the meaning of the place-names was generally apparent. There would, of course, be exceptions, as in the Hottentot name for Cape Town *//Hui-!geis*—with reference to which Krönlein and Prof. Hahn, both experts, suggest two quite different, yet equally appropriate meanings; the former connects the first part of the name with *//hui*, to rear the head of a snake, while Hahn ("*Tsuni-//Goam*, the Supreme Being of the Khoi-Khoin," 1881, pp. 34-35), connects it with "*//hu*, the root of a word meaning "to condense," hence *//hus*, an old word for *cloud*, which word is still used. In the one case the word refers to the mountain upreared at the back of the town, in the other to the dense mass of cloud which forms so frequently on the top of the mountain. There may be an instance or two of this sort, but for the most part the meaning of the Namaqua-Hottentot place-names can be traced; and, as might be expected from a primitive people, are almost entirely descriptive, setting forth some physical feature of the locality named, or something concerning its fauna or flora. There are very few that have reference to events, and, where they have such reference, the events are of a comparatively trivial nature; yet in that sense they may be called historic. To the former belong such place-names as: */Ao-//gams* (Hot. */ais*, fire; *//gami*, water; the *s* is locative), this is the Hottentot name of both Warmbad and Windhoek in Great Namaqualand, the reference being to the hot springs at these two places. *Guidaos* (Hot. *guib*, *Euphorbia mauretanica*: *daos*, a poort). Melkboschpoort, Great Namaqualand. *Kham daos* (Hot. *xami*, a lion; *daos*, a poort). Lion Poort.

/Kara-Khois (Hot. */Kara*, separate, peculiar; *Khois*, a woman), which the Dutch have made Bijzondermeid. To the latter belong such place-names as: *Gobabis* (*‡Koab*, elephant; *//gub*, a tooth), a place in Damaraland, so named because a large quantity of ivory was once found there sunk in the mud. *Kams* (Hot. *!Kam*, to fight), a place on the road from Leliefontein to Pella, Little Namaqualand, said to have been the scene of a tribal battle. *Troe-troe* (Hot. *toro*, to make war). Tradition says that in the neighbourhood of the river thus named (on which the township of Van Rhyn's Dorp now stands), a big fight took place between two Hottentot tribes. over some Hottentot Helen. To *Prieska* (*beris*, a she-goat; *ga*, to be dead, to be lost) reference will be made later on.

A careful examination of a good map like Horne's "Map of the Cape of Good Hope and Adjoining Territories," 1895, reveals the fact that beside: (I.) place-names, that may be described as being pure or real Hottentot names, there are: (II.) Hottentot place-names that have been corrupted, (a) on the western side of the sub-continent, by the intrusion of Europeans from the south, (b) on the south-eastern side, by the intrusion of Kaffirs from the north, and others at a later period by the intrusion of Europeans from the south. (III.) Hottentot place-names that have been translated into Dutch or English equivalents. (IV.) Hottentot place-names that have been displaced and superseded by European place-names of an entirely different meaning.

I.—True Hottentot Place-names.

A few Hottentot place-names in their unadulterated form have already been mentioned; a glance at a few others will indicate how exactly the salient feature or features of the places named are depicted in the designations given to them. The Koranna Hottentot name of the place near the Asbestos Mountains, known to Europeans as Rietfontein, where Messrs. Anderson and Kramer established a mission in 1801, is given by Lichtenstein (II., p. 239, 1815) as *Aa 't Kaap* (Hot. */a*, a vlei; *!ab*, a reed), the European name being practically the same in meaning as the Hottentot. *Ababis*, in Namaqualand, is from Hot. *abas*, a calabash, and is so named, Prof. Hahn says ("*Tsuni //Goam*," p. 108, 1881), "on account of calabashes growing there in great abundance." *Daweros* is the name of a place in Great Namaqualand situated between Bethanien and Berseba; it owes its name to the *Tamarix articulata*, known to the Namaquas as *daweb*; this word, in its anglicised form, *dabby* or *dubbee*, is of frequent occurrence in Namaqualand place-names. *Goubus* (Hot. *‡aoub*, a wooden water-trough) is the name of a small place at the foot of the Kamiesberg, Little Namaqualand, concerning which Thompson ("Travels," p. 298, 1827) says:—

> "Here with difficulty we procured water, by digging in some old pits, between the masses of the rock, which form a sort of basin or

trough, in which the rain-water is collected. It is from this circumstance that the spot derives its name—*Goubus* in the Bushman (!) language, signifying Trough Fountain."

The extensive limestone plateau in Griqualand West, now known as the Campbell Rand, is known to the Korannas as the *‡hab*, this word has been europeanised into '*Kaap*, it means a large plain. In the centre of Great Namaqualand there is an extensive plain marked in Alexander's map (long. 17, lat. 25) which he calls " the *Keikap* or Great Flat " (I., p. 91, 1838); here again we get the Hottentot word *‡hab*, a large plain, preceded by the adjective *gei*, great. This name must not be confounded with that of a river in Great Namaqualand known as the *Keikap*—another instance in which similarity of printed appearance could easily mislead. This latter *Keikap* means in English " The Witch River " (cf. the Hex Rivier of the Cape Province); it is formed from the two Hottentot words *!geib*, sorcery, wizardry; *!ab*, a river. " *Kamop*, or Lion River," is the name given by Alexander (I., p. 227, 1838) to the river south of Keetmanshoop, which, forty odd years earlier, Le Vaillant (" New Travels," II., p. 259, 1796) gives in the form " *Gamma River* "; it is derived from the Hottentot word *xami*, a lion, a word which enters into the composition of many other place-names both in Great Namaqualand and elsewhere in South Africa, as *Kham |asas*, the lion's well; *Kham daos*, Lion Poort, already mentioned; *Khamis*, Lion Valley; *Chamika*, the Lion River, the name of the river near Uniondale, now known as the Potjes River. We shall refer to *Gamka* later on.

The name of the river on which the township of Avontuur stands is given by Sparrman and Paterson (see their respective maps, the latter a reproduction, apparently, of the former) as the *Kukoi*, with reference to which Sparrman says (I., p. 305, 1785): " or as it is pronounced, *t'Ku t'Koi*. This name signifies head or master." Later (II., p. 257, 1785) he uses the term in the same sense: " When they saw that in order to get tobacco nothing more was necessary than to be a captain, they presented to me several others of the party as being likewise *t'Ku-t'Koi*, or captains." The name appears to be derived from the two words *!Khub*, master; *Khoib*, a man. In the two Hottentot names *O'ogami* and *O'okiep*, the first syllable in each represents the Hottentot word *|u*, saltish, brackish: in the former (the name of a water-place near Angra Peguena), the latter part of the name is *||gami*, water; in the latter name *O'okiep* (which, until quite recently, was the centre of the copper mining industry of Little Namaqualand) the latter syllable represents the Hottentot *gei*, to be great. *Tradouw*, the name of the pass in the Swellendam district, C.P., running through the Langebergen, from Zuurbrak to Barrydale, is formed from the two Hottentot words, *taras*, a woman; and *daos*, a poort. (*Cf. Traka*, from *taras*, a woman; and *!ab*, a river.)

II.—Corrupted Hottentot Place-names.

(a) Hottentot place-names that have been corrupted are numerous, so corrupted in some instances as to be apparently beyond recovery. Indeed, had there been collusion on the part of early travellers, authors and others to mystify students of later years, they could hardly have succeeded better than they have done. For instance, the name which now appears on the map and elsewhere as *Trekkentouw*, a river of the George district, C.P., has been given many different forms of name by various authors, some of whom gave more than one form. They are as follows:—

1795, Thunberg, "Travels," I., p. 183, *Krakakou*; 1796, Le Vaillant, "Travels," I., p. 173, *Krakede-Kau*; 1805, Semple, "Walks and Sketches," p. 154, *Traqua de Cou*; 1809, Collins, Moodie "Record," V., p. 29, *Trakete Kouw*; 1812, Lichtenstein, "Travels," I., p. 193, *Krakadakouw*; map, *Trakadakouw*; 1818, Latrobe, "Journal," p. 152, *Trekata 'Kow*; 1827, Thompson, "Travels," p. 6, *Traka-da-Touw*; map, *Trakudiku*; 1835, Moodie, "Ten Years in South Africa," II., p. 9, *Trakant, 'Kaw*; 1837, "Government Ordinance," No. 12, *Trek-aan-de-Touw*; 1844, Backhouse, "Narrative," p. 130, *Trakadataow*; 1919, present form, *Trekeatontow*, or *Trekkentouw*.

The Government attempt is a pretty piece of folk-etymology. This, though an exceptional case, will suffice to show something of the puzzles and problems that confront the student in his endeavours to ascertain the original form and meaning of a corrupted Hottentot place-name. This name is said to mean, in its original form, "The Maiden's Ford," which would suggest that the former part of the name is to be referred to Hottentot *taras*, a woman; and the latter part to *daob*, a way or path.

Other place-names of this class may be discussed: *Aughrabies* and *Hantam* were dealt with in my paper at the last meeting of the Association, and may be referred to in the Journal, vol. xvi., p. 439 (1919-20). *Eikhams* is the form which the Hottentot name */Ai-//gams* (Hot. */ais*, fire; *//gami*, water), applied to both Warmbad and Windhoek, has now assumed. *Garies* (Hot. */garieb*, couch-grass, or kweek), the place of couch-grass, it is in Little Namaqualand; there is also a */Garis*, with the same meaning in Great Namaqualand. *Koussie*, now the Buffels Rivier, in Little Namaqualand, and at one time the border of the Colony in that direction, is the present form of the Hottentot */Gaosib* (*/gaob*, a buffalo or wildebeest). In each of these cases the difficulty appears to have been the clicks. *Swakop* is the form of the Hottentot *Tsoa-xoub* (*tsoa*, a hole; *xoub*, excrement, of men and birds). The latter part of the name appears in another Namaqualand place-name, *Ani-xoub* (Hot. *anib*, a bird, *xoub*, excrement), but it has been assimilated to the Dutch *kop*. Another instance of assimilation to this Dutch word is afforded by the name of a place not far from Postmas-

burg, Griqualand West, where the original Hottentot name *!Awes*, the vaalbosch, *Tarconanthus camphoratus*, has been corrupted into *Koppies*. *Gantouw*, spelt *Candauw* in "Het Dagverhaal van Plettenberg's Landryse," is a fair European reproduction of the two Hottentot words *!Kani*, the eland; *daos*, a poort, of which this name of a poort in the Hottentot Holland mountains is composed, and by which it was known in early days, "De Cloof van het Gebergte die door de Hottentots *Gantouw* werd gen^t en door ons Elandspat" ("Dagverhaal" of Hartogh's cattle-trading expedition, 1707). *Karas* Mountains is the name given by Alexander (I., p. 276, 1838) to that range of mountains in Great Namaqualand, which was for many years the headquarters of the Bondelzwart-Hottentots. It was here that for two years they defied the Germans, by whom, however, they were subjugated in 1908. Tindall ("Two Lectures on Great Namaqualand," p. 16, 1856) gives us this name in the form "*Xgharas*." It is said to be from the Hottentot *!a-as*, sharpening, whetting, and to refer to the sharp character, or the sharpening character, of its loose stones. The chief mountain of the range was named by Alexander "Lord Hill"; the Germans recognising, apparently, the appropriateness of the Hottentot name, called it "Scharfenstein." A curious hybrid place-name is furnished by Robert Moffat ("Journey from Colesberg to Steinkopf in 1854-5," p. 155, 1858) in the name *'Nougat Pass*, in which no less than three different languages are represented, viz., Hottentot, Dutch and English. *!noub* is the Hottentot name for the ochre with which, mixed with fat, the Hottentots smeared themselves; *gat* (hole) is the Dutch word for the cave from which this material was obtained; and *Pass*, of course, is English. This is the name of a pass at the northern end of the Doornberg range, near Prieska, C.P.

Prieska is mentioned last in this class because it affords an opportunity of dealing with one or two points in connection with this name raised by Kingon in his fine paper on "Aboriginal Place-names" (South African Journal of Science, vol. xv, p. 758).

The early printed form of this place-name as it appears in the account of H. van de Graaff's "Journey to Bechuanaland," in 1805, is *Priskab*, said there to be the Koranna name of a drift in the Orange River. Robert Moffat ("Journey from Colesberg to Steinkopf in 1854-5," p. 155, 1858) gives us "*Brieschap*," and Burchell (I., p. 307, 1822) spells it "*Brieskap*" (Hot. *berib*, a he-goat; *beris*, a she-goat; *ga*, to be dead, to be lost). Thorough analyses of the word show many interesting points, especially if taken letter by letter.

P.—Why is the initial letter written by some *P*, and by others *B*? Because the Hottentot pronunciation of these letters was scarcely to be distinguished. Campbell ("Travels . . . . Second Journey," II., p. 305, 1822), speaking of the Great River, says that the "Corannas call (it) the *Gareep* or *Gareeb*, it being difficult to distinguish which. This may account for the fact that Dr. Bleek ("Comp. Gram. of the South African

Languages," p. 21, 1862) spells the Hottentot word for a goat, *pirip*, while Krönlein does not appear to recognise the *p* at all in Namaqualand-Hottentot, and spells it *berib*.

E.—Why has the *e* of *beris* disappeared from the place-name? This is to be explained by the fact that the *e* in this word is, as it is marked by Krönlein, very short, indeed it is only a half-vowel—" wie die hebräischen Schewa."

R.—Of this letter in the place-name Kingon asks: " What is the English *r* doing there? " It is not the English *r*, but the Hottentot *r*, which does not represent a guttural sound as in Kaffir, but as Krönlein says: " ist mit der Zungenspitze zu sprechen." Kingon (p. 761) assumes that the Dutch *g* is the equivalent of the Hottentot *r*, a mistake which runs through the whole of his " H.-B." section and vitiates much of his argument.

IE.—The diphthong *ie* represents the long sound of the *i* in *beris*, which is like that of the double *ee* in sheep.

S.—In the Hottentot language the suffix *s* indicates the feminine, as the suffix *b* indicates the masculine gender: *e.g.*, *aos*, woman; *aob*, man; *|goas*, daughter; *|goab*, son; *beris*, she-goat; *berib*, he-goat.

KA.—The *k* here instead of the *g* (*ga*, to be dead, to be lost) is explained by the fact that the Hottentot *g* approximates more in sound to the English *k* than the English *g*—" *g* ist hart, fast wie *k* auszusprechen " (Krönlein). This accounts for the apparently indiscriminating use of these letters by Europeans in writing Hottentot place-names in which this sound occurs. It is of no little interest here to note that the Hottentot word *berib* occurs in the name applied by the Hottentots to the Bachapins. Burchell says that the Bachapins were " called *Bri*quas, or Goat-men, in the Hottentot language " (I., p. 364; II., p. 303).

Kingon asks further: " If *Gamka* is abounding in lions, why is not *Prieska* abounding in goats? " The answer is that whether *Gamka* means abounding in lions or not, *Prieska* could not mean " abounding in goats," because it does not conform to the Hottentot usage, which requires that the gender sign, *b* or *s*, shall be dropped from the noun before the adjectival particle *xa* is affixed; this would give not *berisxa*, but *berixa*, the word which is used for a man who owns many goats.

It is rational to correct statements or suggestions as soon as one is convinced that they are really wrong; an opportunity is taken to correct the statement made in my " Notes on South African Place-names " (p. 4, 1914), that the *-ka* of *Gamka* was the Hottentot adjectival *-xa*, with the force of abundance. (This correction does not, however, affect what has just been said *re Prieska*). Kingon's paper drew my attention incidentally to one or two points the consideration of which led me to the conclusion that the syllable *ka* affixed to so many Ciskeian place-names (*e.g.*, *Chamika*, *Dwyka*, *Gamka*, *Kouka*, *Traka*, etc.) was not the Hottentot adjectival *xa*. That these names, occurring in territory concerning the Hottentot occupation of

which in comparatively recent times there is abundant evidence, are of Hottentot origin, there appears to be no serious question. But if the *ka* is not the Hottentot *-xa*, what is it? *Gamka*, which Thompson (p. 153, 1827) spells *Ghamka*, and Collins (Moodie, "The Record," p. 25, Part V.) spells "*Ghamgha*," is mentioned in the "Dagverhaal" of Governor Plettenberg's Journey, 1778, and is rendered "Leeuwen Rivier." *Traka* is mentioned in the same document and is rendered "Vrouwenrivier," while Barrow (I., p. 101, 1801) explains it as meaning "Maiden River" (*cf.* Kaf. *Intombi*, the name of a river in Pondoland, and of another in the Transvaal). *Kouka* is also mentioned in the same document—"de *Kauka* of Buffelsrivier" (here we get *|gaob*, a buffalo, again), (*cf. Koussie*), which proves that *Kouka* is not a variant spelling of *Coega*, as Kingon suggests.

Thompson ("Travels," p. 155, 1827) speaks of "the *Dwyka* or Rhinoceros River," but whether he intends us to understand that "Rhinoceros River" is the translation of *Dwyka*, or simply the European name, is not clear. *Chamika* is mentioned by Sparrman (I., p. 304, 1785) as the name of a branch of the Kamanassie River. He says: "Pott-rivier is likewise called *Chamika*" (probably our Potjes Rivier). The first part of this name, and also of the name *Gamka*, is the Hottentot word *xami*, a lion; while the first part of the name *Traka* is to be referred to the Hottentot word *taras*, a woman. In each of these names there can be little doubt that the final syllable *-ka* represents the Hottentot word *!ab*, a river. This is supported by the name *Ai-!ab*, the Liver-river, in Great Namaqualand. This name occurs in Willem van Reenen's "Journaal" (1792) in the form *Eym+Kaap*—"De Leeverrivier of *Eyn+Kaap*." (Molsbergen, "Reizen in Zuid-Afrika," II., p. 145, queries "Leeverrivier," and suggests that it should read "Leeuwerivier," but van Reenen was right). We then get the word *!ab*, a river, in a European guise in the name *Kei-kap*, the "Witch River," to which we have already referred. It appears also in the form *gap* in *Hykaregap* (Karreehoutrivier) also mentioned in Willem van Reenen's "Journaal" (1792), and in the form *koa* in the name *Kamkoa* (the Hottentot name of the Hartebeestrivier), mentioned in Wikar's account of his sojourn among the Namaquas 1779 (Molsbergen, II., p. 115). And then finally we get in the form *K'a* in Wreede's "Hottentot Woordenlijst" (1707), where it is rendered Dutch, "een rivier," and Latin, "fluvius"; and *Ka* in the river names mentioned above.

From what has been said above it must not be understood to mean that the Hottentot adjectival *-xa* does not occur in our place-names. That would be a mistake, as we think can be made to appear. Referring to the name *Coega*, which Sparrman (II., p. 17, 1785) spells "*Kuga*," and Paterson (p. 83, 1789) *Kow Cha*, Kingon says: "The only point really at issue is the initial letter, and the correct form must be either Kura, Qura or Xura, with the probabilities on the second, and most

of all upon the third form." There is a Hottentot word which is descriptive of the locality, the initial click of which is that which Kingon declares to be the most probable form, which word approximates very closely, if not exactly, to the sound of the present place-name: it is the word *//Khuxa* (Hot. *//Khub*, a thorn, mimosa), abounding in thorns or thorn-trees. (The // click of the Hottentots is the same as the *X* click of the Kaffirs.) I suggest this as a possible origin of the place-name *Coega*, as the word appears to meet the need in every respect.

Gaika's Kop is one of the names referred to by Kingon as having "historic associations," but the Kaffir name of the mountain does not appear originally to have had any reference to the famous Xosa chief Gaika, so well known in connection with the wars between the Kaffirs and the colonists. The "historical associations" appear to be a recent accretion due to a corruption or misunderstanding on the part of the colonists of the Kaffir name of the mountain—*u Ntab'egqira* (K. *in Taba*, a mountain; *i Gqira*, a doctor, one who professes to discover witches), who have confused it with that of the chief, the proper Kaffir form of which is *Ngqika*. The somewhat similar sound of the chief's name *Ngqika* to that of the name of the mountain, *Gqira*, appears to have misled the colonists into connecting the mountain with the chief, hence its present name. It is, however, referred to here because the *-ra* of the Kaffir name of the mountain is nothing other than the Hottentot adjectival *-xa*. The Hottentot word *!geib* is the name given to the witch-doctor's paraphernalia to-day in Namaqualand; *!gei-aob* (lit. witch-man) is the wizard, or the witch-doctor; *!geixa* is the adjective formed from *!geib*. The initial click is nearly the same as that of the Kaffir word; indeed the Hottentot word *!geixa* is practically identical in form and meaning with the Kaffir *i gqira*, of which there can be little doubt that it is the origin. (Dr. Bleek (C.M. Mag., I., p. 202, 1857) speaks of "the readiness with which the Kafirs adopt Hottentot manners and words," and remarks further: "it is certainly remarkable that not one instance has yet been shown where the Hottentots have in the like manner imitated their eastern neighbours.")

The name *Qora* is applied to a river in Gealekaland, Transkei, but it was also an earlier name of the Bushman River, Albany district, C.P. In earlier days the natives are said to have made their pipes from the clay found on the banks of this river. May not the name be derived from the Hottentot word *‡goab*, clay, mud (the click is the same), the adjective formed from the word being *‡goaxa*? That this affix *-xa* was so used by the Hottentots in the naming of localities appears from the Little Namaqualand place-name *Kamakas*, which Alexander ("Expedition," I., p. 89, 1838) renders "red-clay." The former part of the name is the Hottentot word *‡gama*, brown, to be brown; the final *s* is locative; the remainder of the word is the adjectival *-xa*, signifying abundance; the real Hottentot name of the place is *‡Gamaxas*, the place of red clay.

May I venture to submit that there is very little difference here also, when the locative *s* is dropped, between the sound and the meaning of this place-name and that of the Ciskeian *i Qumra* (Komgha), which means finely powdered red clay. Kropf says ("Kaffir Dictionary," *in loc.*) that this place "took its name from the red clay mines in the neighbourhood."

We are compelled to recognise, I think, that the *ka* of *Prieska* is not of necessity the *ka* of *Gamka*, nor is the *ga* of *Coega* in any way related to the *ga* of *Quagga*, as will appear later; nor are either of the two latter found to have any connection with either of the two former; while the *ga* of *Coega*, the *ra* of *i Qumra*, and the *gha* of *Komgha* are really the same, and are three of the several forms which the Hottentot adjectival particle *-xa*, signifying multitude, plenty, abundance, has assumed.

(b) A great deal of earnest, persistent research on the part of adequately equipped scholars will be needed before the corruptions of Hottentot place-names, due to the intrusion of the Kaffir element into territory previously occupied by Hottentots, are likely to be elucidated, and Kingon's contribution is heartily welcomed as a distinct advance in that direction. He will not, we feel sure, object to any queries, suggestions, or criticisms that may be helpful to that end. One is bound to say at once that what Kingon appears to regard as a quite recent discovery, viz., that Kay's statement ("Travels and Researches in Caffraria," p. 268, 1833) that "the names of different rivers to the eastward of this point (Butterworth) are purely Kaffer" needs to be corrected, was more than suggested seventy years ago by Appleyard ("The Kafir Language," p. 10n., 1850), in the following passage:—

> "Most of the rivers west of the Kei, and some even beyond that river, still retain their Hottentot names, except that the Kafirs have conformed them to the laws of their own language";

and a few years later Dr. Bleek ("Researches into the Relations between the Hottentots and Kafirs," "Cape Monthly Magazine," I., p. 203, 1857), says:—

> "Other evidence, in which that of the names of localities is principally to be mentioned, must lead to the conviction that the Hottentots extended formerly far more to the north-east than we have any historical record of. Several hundred, perhaps a thousand or more years ago, they occupied probably the whole of the present Kafirland, most likely as far as Natal."

That these statements are in accordance with fact has been generally conceded by students of the subject from Appleyard's day on, and evidence of their correctness is gradually but constantly accumulating as the place-names in the territory concerned are more closely examined.

What has already been adduced goes to prove that it is a result to be expected that many of the place-names of the earlier occupants of a territory would be corrupted by an intruding people of different speech, while others would be entirely superseded; but it also goes to prove that distinct traces

of the earlier occupants would remain in the nomenclature of the territory as a proof of that earlier occupation. This is undoubtedly the case in both the Transkeian and Ciskeian territories. Evidences of Bushman occupation are not wanting, for, in addition to their paintings, such place-names as *Baroeng* (Ses. *mo Roa*, a Bushman; Pl. *ba Roa*, Bushmen), near Little Roma, Basutoland, "the place of the Baroa or Bushmen"; *u Daliwe*, the Kaffir name of the Thorn River, Cathcart district, C.P., derives its name from a cave on its bank containing *daliwe*, Bushman paintings; *Ubala amatwa* (Kaf. *uku Bala*, to write; *um Twa*, a Bushman), a locality in the Tsolo district, Transkei, which name also refers to local Bushman drawings; *Keang-kop*, north-east of Kuruman, British Bechuanaland, preserves for us the designation of the Bushman sky-god (Arbousset and Daumas, "Narrative," p. 253, 1846). *Ngoliloe* (Ses. *ngola*, to engrave, draw), a place in the Ficksburg district, O.F.S., is a name that refers to the Bushman paintings (Ellenberg, "History of the Basutos," p. 91, 1912), and others may be adduced. Evidence of Hottentot occupation is not wanting, as we have seen; but including them all in a common "H.-B." category must not be taken to mean that Bushman and Hottentot place-names can never be distinguished. It is true that at present only the most meagre and inadequate information is at our disposal respecting the former, and it would almost appear that the opportunity for largely increasing that information had already passed away, yet when we remember how much has been accomplished in the northern hemisphere, by the study of place-names derived from languages that have been dead for centuries, to recover the history and wanderings of races which have left no other record behind them, may we not hope that some day future students may succeed in accomplishing something of the same sort in the southern hemisphere? Resources do not appear to be absolutely exhausted while any of the Bushmen of the Kâlahari and Lake N'gami regions, or the Pigmies of the tropical forests of Central Africa, exist, and it is devoutly to be wished that they may not be exterminated as ruthlessly as the Bushmen of the south have been.

A.—The -ra Group of Place-names.

This, with several other groups of place-names arranged by Kingon according to their respective terminations, are all classed by him under the heading: "Hottentot-Bushman Place-names," which brings them within the scope of this paper.

After reading very carefully the section headed as above (p. 752), it appears to me that there are *three* statements made that need some modification: (a) That "-ra is Bushman rather than Hottentot" (p. 758); (b) that "-ra is diminutive in force" (p. 758); (c) and that "it seems certain that all these different spellings (-ra, -ka, -ga, -gha, -qa, -qua, -cha) were attempts to fix one and the same sound, the sound which we designate nowadays, -ra" (p. 759).

(a) First of all one would like to know what authority exists for the statement that "*-ra* is Bushman rather than Hottentot." Made so definitely, it should surely be capable of actual proof, or shown to be a legitimate inference from already ascertained facts. Where is the proof, or what are the facts from which the inference is made? A careful examination of Bleek's "Comparative Grammar of the South African Languages," of Bleek and Lloyd's "Bushman Folklore," of Bertin's "The Bushmen and their Language," and, indeed, of everything available that would be likely to yield information on the subject, has resulted in the discovery of no such Bushman affix, nor of anything to suggest that there was such an affix.

There are two considerations which appear to indicate quite the converse of Kingon's statement:—

1. Bleek and Lloyd ("Bushman Folklore," p. 144, 1b) give *-ka* as a Bushman "affixed genitive particle corresponding with English *'s*, Hottentot *-di*. After a long vowel its consonant is pronounced more softly, almost like *g*, and after a short vowel more strongly, approaching *kk*." Bertin ("The Bushmen and their Language," p. 69, 1886) also gives *-ka* as the mark of the genitive, while on p. 61 he speaks of the "strong explosive *k*." (Bleek and Lloyd, p. 152, give another *-ka*, a particle indicating, they say, probably the perfect or the subjunctive of the verb.) The point is that neither Bleek and Lloyd nor Bertin give the least hint of an affixed particle *-ra* in the Bushman language; even the last syllable of the word *Quagga*, included by Kingon in his "*-ra* Group," has not the guttural sound in the Bushman language. Bleek and Lloyd (p. 122) spell it */Kwakka*.

2. The particle *-xa* in the Hottentot language (so spelled by both Krönlein and Seidel, *-gha* by Tindall) is explained by Krönlein as the adjectival ending, and as indicating the abundance, multitude, size, strength of the quality or thing denoted; so it is that *xami*, a lion, becomes *xamxa*, abounding in lions; *berib*, a goat; *berixa*, rich in goats; *//khub*, a thorn, mimosa; *//khuxa*, abounding in thorns; and so on. As we have already pointed out, the noun drops the masculine suffix *b*, or the feminine suffix *s*, and forms the adjective with the suffix *-xa*. For these two reasons: (1) That there does not appear to be any record of a Bushman guttural suffix *-ra*; and (2) that there certainly is such a Hottentot suffix *-xa*, or *-gha*, it would seem that something more than the mere assertion that "*-ra* is Bushman rather than Hottentot" is needed to establish that statement.

(b) The statement that "*-ra* is diminutive in force" (p. 758) is undeniable so far as the affix *-ra*, as used in Kaffir, is concerned, there it is affixed to an adjective to express diminution of the *quality* indicated by the adjective (*e.g.*, *Ihashe libomvura*, the horse is reddish: *bomvu*, red), but does it follow that when *-ra* is used in Kaffir as the final syllable of place-names that are admittedly other than Kaffir in their origin, it

must of necessity have the same force or meaning? Either this should be made to appear, or the statement should be guarded or modified. Both Kropf and Godfrey refer this particle to "the Hottentot adjectival ending which has been accepted by the Kafirs and affixed to nouns and adjectives." The force of the particle has, however, been altered. (See Kropf's "Kafir Dictionary," *-ra.*)

(c) Early spellers went wrong, not only in clicks and vowels, but also in consonants and gutturals; examples of this we have in the unhappy jumble of *t's* and *k's* in the various forms which the place-name now given as *Trekkentouw* has at various times assumed. Campbell mentions the difficulty in distinguishing between the sounds of the Hottentot *b* and *p*. According to Burchell (II., p. 255) a final *p* is sometimes silent, or nearly so, and the *r* sound is used for *b* in the Kora Hottentot. The name *Gouph* (*/houb*, fat) appears in the forms *Coup*, *Choup*, *Kaub*, *Koub*, and *Gouph*, a final *b* becoming *p* and *ph*, while an initial click becomes in turn *C*, *K* and *G*, to say nothing of not a few other like curiosities. That this puzzling interchange of letters was not always due to the inability of the writers to appreciate the different sounds, but sometimes to slovenly or indistinct utterances on the part of the natives themselves, appears from Thompson's remarks ("Travels," p. 94 n., 1827):—

> "At the same time it must needs be owned that the articulation of the natives, in many cases, appears so indistinct to a European ear that the strange diversity in the orthography of proper names in the works of different travellers is not at all surprising."

In the face of these facts to include in a common group place-names ending in "*-ra*, *-ka*, *-ga*, *-gha*, *-qa*, *-qua*, *-cha*," as if these particles were not only the result of attempts to produce, in known characters, "one and the same *sound*," but as if they all had one and the same *meaning*, appears to be likely to lead to confusion worse confounded; *e.g.*, is it not misleading to place the word *Quagga* in this "*-ra* Group of place-names? That is, if the word is what it is generally regarded as being, viz., the onomatopoetic name of *Equus Quagga*, imitating the peculiar cry of this animal. A writer in the "Scientific African" (p. 72, 1906) says:—"The Quagga is so named onomatopoetically, being an imitation of the peculiar bark of the animal, sounding like *quog-ga*, the last syllable being very much prolonged." According to Kolben ("Beschreibung des Vorgeburges der Guten Hoffnung," p. 25, 1745), this word in the form *Qu-aiha* was applied by the Cape Hottentots to the donkey, being possibly the name of the *Quagga* applied to an animal that was new, but not unlike it. But there can be little if any doubt that the word is onomatopoetic in origin. Then the name *Commadagga* is another final syllable of which, *-ga*, does not appear to give it right of place in this "*-ra* Group of place-names." It is to be referred to the two Hottentot words, *!homi* (a hill, mountain), and *darab*, *Cannabis sativa*, dagga, or wild hemp, and really means *Daggaberg*; Sparrman's initial, *Quammedacka*, representing the above click.

We must recognise then, I repeat, that the *ka* of *Prieska* is not, of necessity, the *ka* of *Ganka*, nor is the *ga* of *Coega* connected in any way with the *ga* of *Quagga*, nor is either of the two latter in any way related to either of the two former, and that the *ga* of *Commadagga* is another *ga* still. The meaning of the particle in any given case can only be determined by a close and careful inquiry into the origin of the place-name concerned. My own generalisation, quoted by Kingon on p. 758, was right as to the Hottentot origin of the names mentioned, of that I am convinced; but it was wrong in suggesting that *-ka* and *-ga* were the same in meaning in each case specified, as I think that now I have sufficiently shown.

B.—The -Kama Group.

In the Namaqua-Hottentot language the word for water is *//gami*, and there can be little doubt that *Kamma* is the form which this word assumed among the colonists in comparatively early days; for in Wreede's Hottentots Woordslijst (compiled about the middle of the seventeenth century, and apparently irretrievably lost until it was discovered quite recently among the archives in Holland by Molsbergen, who prints it in his "Reizen in Zuid-Afrika," I., pp. 215-224), the word *Kamma* appears, and is given as the Hottentot word for—Dutch: "Rivier of Water"; Latin: "Fluvius *vel* aqua." It also appears in the same form in Kolben's Hottentotse Woordelijst (1727): "Aqua & omne liquidum—*Kamma*—water of andere vloeibare stoffe als wijn, bier"; or as it appears in my German copy (p. 25, 1745): "Aqua & omne liquidum—*Kamma*—liasser und alles flussige," and yet again (p. 26), "Fluvius—*Ka'mma*—Fluss."

Most of the place-names having this termination, as Kingon points out, are Ciskeian, only three occurring in the Transkei, viz., *Mgakama*, *Qokama* and *Sulenkama*. The remaining thirteen which Kingon gives are to be found in various parts of the south-eastern section of the Cape Province. To these a few others might be added, which are not now in use, but which appear in the journals of early Dutch explorers, *e.g.*, Molsbergen ("Reizen in Zuid-Afrika," II., p. 8) gives us a *résumé* of the "Dagverhaal" of Jan Hartogh's Landtocht (1707), in which is mentioned as situate three hours from the Botrivier, de "Swarte Rivier door de Hottentots *Doggha Kamma* gent." Farther on (pp. 9-10) the Steenbook Rivier is mentioned, "van de Hott. gent. *Gam dachama*"; and "het warm water door Hott. gent. *Disporteamma*." Valentyn ("Beschrijvinge van de Kaap der Goede Hoope," p. 96, 1726) gives us "*Tharakkama* (dat is ruige rivier)" as the Hottentot name of the Olifants Rivier on the west coast (Hot. */Kora*, rough; and *//gami*, water. In Wikar's account of his travels in Little Namaqualand (1779), presented to Governor Plettenberg (Molsbergen, II., pp. 105-108), he mentions "*Toelykamma* of litteekenwater." Then Stow ("Native Races of South Africa," p. 205) gives us "*t'Nuka-*

t'Kamma, i.e., Grassy Water," as the name of the Lower Sundays River. Hartogh mentions also "een droge rivier '*Onkamma*' in het Hottentots."

That these additional names as well as the majority of those mentioned by Kingon are corrupted Hottentot names is beyond question. *Gattikamma*, rendered by the Dutch Klaarwater (the place now known as Griquatown), is from the two Hottentot words *!gatsi*, clear, bright; and *//gami*, water. *Keiskamma* is spelt by Ensign Beutler (1752) "*T'hyskamma*" (see Godlonton and Irving: "Narrative of the Kaffir War of 1850-51-52," p. 161 n., 1852). Sparrman spells it (1785) "*Kaisi-Kamma*"; Van Reenen's Map (1792) "*Keis Kamma*"; and Paterson (1799) "*Kys Comma*." (Paterson's spelling is generally somewhat eccentric, so far as the names of localities are concerned.) This name appears to have its origin in the Hottentot word *‡keisa*, shining (*cf.* D. *Blinkwater*), of which the Kaffir name of the river, *i Xesi*, would seem to be either an adaptation or a corruption. Kingon says that

> "the very derivation of the name *Keiskama* (originally *i Xesi*) indicates an agreement arrived at between the Kaffirs and the Hottentots, by which the fourth river from the Kei was to be the dividing line between the races." (*Vide* Kropf, "Kaffir Dictionary," *in loc.*)

But Kingon does not give the derivation, and leaves us quite in the air as to the point of contact or of connection. *Noetzekamma* appears to be composed of the Hottentot words *‡nu* or *‡nuse*, black; and *//gami*, water. We get the former word in the name *Nu Gariep*, which Burchell (II., p. 43, 1824) renders "Black River," and in Sparrman's "*t'Nu-t'Kay*" (II., p. 146, 1785), now known as the Zwart Kei. *Kraggakamma* is formed from the Hottentot words *//Karaxa* (a word in which we get the Hottentot adjectival termination, expressing abundance (Hot. *//Karàb*, gravel in a river bed; and then the adjective *//Karaxa*, plenty of pebbles), gravelly, pebbly; and *//gami*, water. *Kwa Kama* (Kingon's "booby-trap"), as is well known, is not to be traced to "an *ancient* chief," but to Kama, the loyal, Christian chief of the Amagqunukwebe, who died as recently as 1875, to whom and his people the Government made a grant of the land in 1838, and who resided there with his missionary, the Rev. William Shepstone, until Sir George Cathcart made a grant (confirmed subsequently by Sir George Grey) to Kama and his people of a more suitable tract of land along the Keiskamma, as a reward for their fidelity to the Government. The name *Kamastone*, which the place now bears, is composed of this chief's name and the last syllable of the missionary's name (Shep-)stone. There is one other name that should be mentioned here, *Keiskamma*, a diamond digging centre on the Vaal River. As I have shown elsewhere (JOURNAL OF SCIENCE, p. 98, 1914), although entirely Hottentot, like the river-name *Keiskamma* of the Old Colony, this name is derived from two Hottentot words quite different in meaning from those from which the river-name is derived.

The Vaal River *Keiskamma* refers to a group of eight camel thorns (*Acacia giraffae*), which stood at one time on the site (*//Kheisa*, eight; *//ganab*, the camel thorn). The place-name was assimilated to the river-name by the diggers, to whom the latter was familiar. It is of interest to notice in this connection the different forms a Hottentot word may be called upon to assume when dealt with by Europeans. Here the word *//ganab*, a camel thorn, as we have seen, assumes the form *Kamma;* then we get it in the form *Guanhop*, the Hottentot name of the Griqualand West township on the Vaal River now known as Douglas (Freeman: "A Tour in South Africa," p. 232, 1851), and again we get it in the form "*Kounobis* or *Tounobis*" (Baines: "Explorations in South-West Africa," p. 120, 1864) the form assumed by the Hottentot name of the place in Damaraland known to the colonists as Rietfontein, and to the Hereros as *Otyimbonde*, which also means a camel thorn.

C.—Other Typical H. (-B.) Names.

"(a) *-ouw* Group."—The termination *-douw* (which sometimes assumes the form *-touw*) as it occurs in our place-names, is derived from the Hottentot word *daob*, a path, a way. The feminine form *daos* means a poort, and occurs in the names *Guidaos* (Hot. *guib*, *Euphorbia mauritanica*; *daos*, poort), known as Melkboschpoort, the poort of entrance into a range of mountains near Bethanien; and *Khamdaos* (Hot. *xami*, a lion; *daos*, a poort), Lion Poort, both in Great Namaqualand. *Gantouw* or *Candauw*, the name given by the Hottentots to a kloof or poort in the Hottentots Holland mountains, is derived from the two Hottentot words *!Kani*, the eland, and *daob*, a path. The "Dagverhaal" of Hartogh's Landtocht (1707) mentions: "De Cloof van het Gebergte die door die Hottentots *Gantouw* werd gent, en door ons *Elandspat*." *Nardouw*, a mountain in the north of the Clanwilliam district, C.P. (there is another mountain of the same name in the Sneeuwberg range) is derived from the Hottentot *‡nara*, flat (like a roof, etc.); *daob*, a path. The name appears in Lichtenstein's account of Kommissaris-Generaal de Mist's "Reis naar het Noorden" in 1803: "Aan de overzijde lag een steile berg met de Hottentotnaam *Nardouw* . . . over de top, die vlak was," etc. *Tradouw*, a mountain pass in the Swellendam district, is a name derived from Hottentot *taras*, a woman; *daob*, a path. (*Cf. Traka*, the Maiden's River, and the *Tradiamacquas*, mentioned in the "Dag Register" of Hendrik Hop's Landtogt—see Molsbergen, II., pp. 51-52—where we get the same word *taras*: "wijders beteekent de naam van *Tradiamacquas* by ons wijven of vrouwen volkeren, dog van waar deese benaming herkomstig is, is ons meede niet mogelijk geweest na te vorsschen." *Spandau*, Lichtenstein's old Prussian soldier notwithstanding ("Travels," I., p. 367, 1812), is almost certainly a disguised Hottentot name belonging to this group, though I have failed to ascertain its original form.)

"(b) *-quas* Group."—The termination *-qua* appended to tribal names has the meaning of people or nation—*e.g.*, Nama-*qua*, the Nama people; Kora*cqua*, the Kora people (Koranas); Bri*qua*, the *berib* or goat people. The place-names *Attaquas* Kloof, *Hessequas* Kloof, *Outeniqua* Mountains, *Sonquas* Drift, etc., refer to features of the respective territories occupied by the tribes or peoples specified; while *Namaqualand*, *Griqualand*, speak for themselves.

"(c) *-as* Group."—Why does Kingon include in this group of "Aboriginal place-names" *Malagas* (Eiland) and *Moeras* River? *Moeras* is the Dutch word meaning marshy or boggy; Ten Rhyne calls it: "*Paludosum* (*Moeras* rivier)," which is given in Churchill's "Voyages" (IV., p. 831, 1704) as "Fenny River." While *Malagas* was the name given to the island in Saldanha Bay because of the large number of a certain sea-bird which was found there, Valentyn (V., II., p. 2, 1726) mentions a sort of bird "die wij doorgaans den naam van *Mallegazen*, *Jan van Genten* (een soort van witte meeuwen en zou van Jacob van Nek genaamt) en *malle meeuwen geven*." These two place-names can scarcely be designated "*Aboriginal* place-names." But perhaps the latter is a misprint for the *Malgas* of the Tsomo district, which may have another derivation.

III.—Translated Hottentot Place-names.

Translated Hottentot place-names continue sometimes side by side with the older name but not infrequently the older name is crowded out altogether by the new name. Buffels Rivier (sometimes in early days called also the *Zand Rivier*, a name eminently appropriate to it as it appeared on the occasion of my first and last visit to it a few years ago) is the Dutch name of a river in Little Namaqualand, but it is a translation of the Hottentot name */Gaosib* (Hot. */gaob*, a buffalo), which has already been mentioned under its corrupted form *Koussie*. The *Fish River* in Great Namaqualand is known to the Namaquas by the name *//Oub*, which appears on our map in the form *'Aub*, and means fish, the name has simply been translated by Europeans for their purpose; the Namaquas retain and use their own name. The *Fish River* of the Cape Province has not been so fortunate, its Hottentot name is now never used, and but very few are aware that it ever had one. Sparrman (II., p. 190, 1785) has, however, preserved it for us in the form "*t'Kau-t'Kai*," the *t'k* in each case representing a different click (Hot. *//oub*, a fish; *!ab*, river), the former part of the word, it will be noticed, repeats the name of the Namaqualand river; it was translated by the Dutch *Visch Rivier*, and then later by English colonists *Fish River*. The *Hart Rivier*, a tributary of the Vaal, is known to the Korannas as the *‡Gaob !Garib* (Hot. *‡gaob*, the heart). Here again the Dutch name is a translation in the first part of the Hottentot word; the second part of the name, *!Garib*, we know as the Hottentot name of the Orange River, that is the river of the

desert (Hot. *!garob*, desert, wilderness). The Hottentot name of a kop situate to the south of the *Aughrabies* Falls is *Nawaptana* (*!nawas*, a rhinoceros; *tanas*, a head), the kop is now known as *Renosterkop* to the entire exclusion of the original, which is mentioned by Henrik Jacob Wikar in the account of his wanderings up and down the Great, or Orange River, given to Governor Plettenberg, dated "Cabo den 18 September, 1779." *Kamkoa* is the Hottentot name of a tributary of the Orange River. It is derived from the word *//Kamab*, a hartebeest; the translation "De Hartebeestrivier" having ousted the original.

The names *Karreehoutrivier* (*Hykaregap*, from *!areb*, Karreehout; and *!ab*, river); and *Klaarwater* (*Gattikamma*, from *!gatsi*, clear, bright; and *//gami*, water), have already been mentioned. The tributary of the Vaal River to which the Voortrekkers gave the name *Vet Rivier*, was known to the Koranna Hottentots as the *Gij Koub* (Hot. *gei*, great; */houb*, the fat of the stomach). The latter part of this place-name, */houb*, is found in the name *Gouph*, occurring in the Cape Province, meaning fat, fertile. *Warmbad*, in Great Namaqualand, translates into Dutch the Hottentot name */Ai-//gams* (Hot. */'ais*, fire; *//gami*, water). The *White Kei* of the English colonist, and the *Witte Kei* of the Dutch, are both translations of the Hottentot name of this river, which is given by Sparrman (II., p. 146, 1785) in the form "*t'Kamsi-t'Kay*, or the white river" (Hot. *!gatsi*, clear, bright; *!ab* river). Sparrman also gives the Hottentot name of the Dutch *Zwart Kei* (II., p. 146), in the form "*t'Nu-t'Kay* or the black river); (Hot. *‡nu*, black (*cf. Noetzekamma* and *Nu Gariep-*); and *!ab*, river); the Dutch name being again a translation of the original Hottentot name. A small branch of the Olifants Rivier, in the Clanwilliam district, C.P., mentioned by Le Vaillant ("New Travels," I., p. 227, 1796), is "called in the Hottentot language *Koignas*, and by the Dutch *Dwars-rivier* (cross-river)"; the Dutch name translates the Hottentot name, the root of which appears to be the word *!gou*, to cross, to go across.

There can be little doubt that there are others of the place-names with which we are familiar which are in like manner reproductions in Dutch or English of the earlier Hottentot names, the appropriateness of which was apparent to the colonist who understood the Hottentot language, and who simply turned Hottentot into Dutch or English as the case might be, with the result that the original place-name soon passed out of memory and no record of it was preserved.

IV.—Superseded Hottentot Place-names.

We will mention one or two Hottentot place-names which remain to us in print, but which have been entirely superseded by later comers. */Ai-//gams*, as we have seen, became *Warmbad* in the south of what is now the South-West Protectorate on the other side of the Orange River, but the */Ai-//gams* farther north became *Windhoek*, though who gave it

this name, and when the name was first given, appear to be quite uncertain. The name of the river on the west coast, emptying itself into the Atlantic, *Olifants Rivier*, was given as early as 1660, when it was discovered by a party of explorers under Jan Danckaert, and was so named because of the large number of elephants, from two to three hundred, which they saw on its banks. But this name supplanted an earlier Hottentot name, which is given by Valentyn (" Beschrijvinge van de Kaap der Goede Hoope," p. 96, 1726) in the form " *Tharakkama* (dat is ruige rivier) " ; this name being from the two Hottentot words */Kora*, rough ; and *//gami*, water. The Hottentot name of the river now known as the *Palmiet*, which is marked on the map of a journey " na de Caap das Aguilhas in den jare 1682 " as " De wilde Rivier de Palmyt Rivier genaamt," is given in Willem van Reenen's " Journaal," 1791-2, as " *Houtema* of Slangenrivier " ; both the Hottentot name and the name that would seem to be its Dutch equivalent have been entirely superseded by the name by which the river is known to-day.

One place-name that is generally regarded as of Hottentot origin is the name *Gamtoos*, a river which runs into St. Francis Bay, near Port Elizabeth, C.P. The name appears in the " Kaaps Dagregister " very early in the eighteenth century in the form " *Gamtouws*," as the name of a Hottentot tribe. Later, as the name of a river, Sparrman, 1785 ; J. van Reenen, 1792 ; Paterson, 1794, all spell the name " *Camtours*." Le Vaillant, 1796, makes it " *Gamtoos*," and Burchell, 1824, has it " *Camtoos*." Was this name originally the name of the tribe, or of the river, or of neither? Where did it originate? These queries are prompted by a statement which is made by Le Vaillant (" Travels," I., p. 238, 1796), who says : " We encamped upon the borders of that of (the river) *Gamtoos*. It derives its name from an unfortunate captain who in a storm was shipwrecked near its mouth." Is there any early record to support this statement?

Some unavoidable overlapping and repetition occurs in this paper. Where it is critical in character it is solely with the purpose of ascertaining the actual facts.

In conclusion, it is gratifying that the subject of South African nomenclature is attracting the increasing attention of scholars and students. Further, it is hoped that some of our younger students, who have opportunities for equipping themselves for South African philological studies, may be induced to take up this important and interesting work.

SNAKE-VENOM AND ITS EFFECTS, ESPECIALLY ON OTHER SNAKES.

By F. W. FitzSimons, F.Z.S., F.R.M.S.,
Director, Port Elizabeth Museum.

Read July 17, 1920.

Experimenting with snake-venom is beset with many difficulties, one being that snake-venom varies in its poisonous properties in the same snake, and is sometimes as much as five times as poisonous as at other times. These fluctuations are due to the season of the year and the general condition of the snake.

Well-fed snakes, fresh from the veld or forest in mid-summer, yield an abundant supply of venom, as would be anticipated, but I have recently ascertained that this venom, when dried, does not yield nearly so much solid extract as when venom is taken from snakes after they have been in captivity for some time without food. In this case the venom is considerably less in quantity, but more concentrated in its poisonous properties, yielding two to five times the amount of dried extract that would be obtained from the venom taken from freshly captured snakes in good condition. Again, if a sample of venom is taken from a snake before sloughing its skin, and also immediately after the process, it will be found that the latter sample of poison is more concentrated than the former, and will yield a much greater quantity of dry extract.

It will thus be observed that the experimenter cannot, with any degree of certainty, determine the exact lethal dose for each species of animal unless he tests each lot of venom with which he is about to conduct experiments.

My attention was first drawn to the fluctuations in the poisonous (toxic) power of venom by the difference in the weight of the dry extract from measured quantities of fluid venom. One day, noticing that a puff adder (*Bitis arietans*), which had been in confinement for six months, was in a very emaciated condition owing to its persistent refusal to eat, I caused it to be removed. Before putting it to death I extracted what venom it had, which was five drops. This was noticed to be less fluid than the venom from fresh puff adders, and yielded three times the weight of dry extract compared with that produced from the venom of fresh snakes of the same species. One drop of this venom was fatal to a fowl, whereas other fowls recovered easily after being injected with two and a half drops of the venom of a fresh puff adder. Another fowl recovered with difficulty after a subcutaneous injection of three drops of the latter venom.

Although one drop of cobra venom and four drops of puff adder venom are fatal doses for human beings, it does not follow that this dosage would always prove fatal, for, besides the varying degrees of vital resistance in the human subject, the venom itself varies in its poisonous properties—one drop at times being as potent as two, three and four drops at other times.

Recently I collected some venom from nine ringhals cobras (*Sepedon haemachates*). These snakes had been in captivity for three months, refusing all food, and had not been artificially fed. The venom could hardly be termed a fluid, for it became sticky immediately after extraction, and in a very short time was dry and hard, furnishing a deep yellow extract of unusual weight for the quantity of venom obtained. The toxic properties of this venom were three times that of fresh good-conditioned snakes of the same species.

In the second edition of my "Snakes of South Africa" it is mentioned that some ringhals cobras which were bitten by boomslangs (*Dispholidus typus*) did not manifest any sign of poisoning. Not being satisfied that the reptiles had been sufficiently well bitten to cause death, I waited until further boomslangs could be obtained. When these were forthcoming I made one of them inflict three full bites into the muscles of the back of an adult ringhals cobra (*Sepedon haemachates*). Half an hour after the bites, blood oozed from the punctures, and to a small extent from the mucous surfaces of the mouth. In two hours the victim died, and a post-mortem examination revealed several large patches of extravasated blood under the skin, chiefly in the vicinity of the punctures. Haemorrhage had occurred into the organs, with the exception of the digestive tract, and about a teaspoonful of blood and lymph was found free in the abdominal cavity.

The blood was in a fluid condition. Some of it was collected and put aside, but it failed to coagulate. A rat inoculated with the blood died in thirteen hours. Another adult ringhals cobra was placed in a cage with a very pugnacious boomslang, which immediately attacked it and inflicted several bites on its back. The boomslang was then removed, and, after about fifteen minutes, blood slowly oozed from the punctures in the ringhals and from the mucous membranes of the mouth. In two and a half hours the ringhals cobra died. Dissection revealed the same conditions of haemorrhage as in the former instance, with the exception that it was more extensive owing probably to a larger dosage of venom having been injected. These experiments demonstrate that the venom of the boomslang is fatal to the ringhals cobra, and that the latter reacts to the venom similarly to warm-blooded animals.

Further experiments showed the ringhals cobra to be susceptible to the venom of the Cape cobra (*Naia flava*), so much so that one full bite is lethal.

INDEX OF AUTHORS.

The complete list of papers read at the Bulawayo meeting will be found on pp. 110-112. Some of the papers listed there are not printed in this Journal.

INDEX OF SUBJECTS.

THE

SOUTH AFRICAN JOURNAL OF SCIENCE:

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Johannesburg, 15th November, 1920

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1920-21

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COMPRISING THE REPORT OF THE

SOUTH AFRICAN ASSOCIATION

FOR THE

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The price of this Journal to the general public is as marked on the front page. Every member of the Association is supplied with one copy free, and may obtain extra copies at half-price. Applications for copies should be addressed to the Assistant General Secretary, P.O. Box 6894, Johannesburg.

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Johannesburg, 31st July, 1921

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